THE ABUNDANCE OF EPIBENTHIC AND PLANKTONIC MACROFAUNA AND FEEDING HABITS OF JUVENILE FALL CHINOOK SALMON (*Oncorhynchus tshawytscha*) IN THE MATTOLE RIVER ESTUARY/LAGOON, HUMBOLDT COUNTY, CALIFORNIA

by

Morgan S. Busby

A Thesis

Presented to

The Faculty of Humboldt State University

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

March, 1991

ERRATA

Busby, M.S. 1991. The abundance of epibenthic and planktonic macrofauna and feeding habits of juvenile fall chinook salmon (*Oncorhynchus tshawytscha*) in the Mattole River estuary/lagoon, Humboldt County, California. M.S. Thesis, Humboldt State University, Arcata, CA 130 pp.

Page 12, last paragraph; 0.02m^2 should read 0.01m^2.

Page 92, Appendix D; 1987 should read 1986.

Page 117, Appendix Z; Totals 154,14,100,100,11.0,10.8,2.9 should read 430,14,93.3,100,28.7,36.3,9.38.

Page 118, Appendix AA; Totals 154,14,100,100,11.0,10.8,2.9 should read 175,9,82,100,15.9,17.4,4.8

Page 126, Appendix II; August 27 should read August 23.

Page 128, Appendix KK; #/m should read #/m^2

Page 130, Appendix MM; # of organisms/m should read # of organisms/m^3

ABSTRACT

Epibenthic and planktonic macrofauna were collected at two sites in the Mattole River estuary/lagoon from June through October 1986 and late May through November 1987. One site was located in the lower reaches of the estuary/lagoon, near the ocean, and was characterized by a predominantly sand bottom. Substrate at the other site, located upstream, was composed predominantly of gravel and was shallower in water depth. Stomach contents of juvenile chinook salmon were analyzed and diet preferences determined based on prey organism abundance in the estuary/lagoon.

Epibenthic samples collected at each site during both years were dominated by the amphipod *Corophium spinicorne*. Isopoda, oligochaetea, and the larvae of trichoptera and diptera (Chironomidae) were among other taxa collected. In 1987, overall mean densities and biomasses of organisms were significantly higher at the upper site. Species composition and patterns of abundance were different between the two years.

Plankton samples collected early during both years contained few organisms as the estuary transformed into a lagoon and gradually became a freshwater environment. Once physical conditions stabilized, Amphipoda, Isopoda, Mysidacea, Diptera, Ostracoda, Hydracarina, and Copepoda were collected most frequently. Copepoda were extremely abundant in samples collected at night in the lower lagoon during 1987. Biomass in October was significantly greater than in other sampling periods

due to large quantities of threespine stickleback juveniles.

In early 1986, juvenile chinook consumed mostly terrestrial insects and aquatic hemiptera. Diptera larvae and adults comprised most of the diet later in the season. Terrestrial insects and aquatic hemiptera were the preferred prey items in 1986.

Diptera larvae and adults were the dominant diet component in 1987. Terrestrial insects and diptera larvae and adults were the preferred prey types. Juvenile chinook relied mostly on allochthnous food items from riverine and windborne sources and did little or no epibenthic feeding.

ACKNOWLEDGEMENTS

I express my deepest gratitude to numerous individuals and organizations who contributed valuable assistance during this study.

I am greatly indebted to my graduate committee: Dr.'s Roger Barnhart, George Crandell and Terry Roelofs of Humboldt State University for their technical guidance and critical review of the manuscript. I also wish to thank James Decker and the personnel of the United States Bureau of Land Management, Arcata Resource Area Office, for their continuous support of this study.

Without the enthusiastic assistance of the Mattole Watershed Salmon Support Group (MWSSG), especially Gary Peterson, Rex Rathbun, Freeman House and David Simpson, this study would not have been possible. The same can be said for Greg Bryant, Phillip Buttolph, Glen Sibbald and Chris Wageman who provided SCUBA diving, and other field or laboratory assistance. Thanks are also due to many former and present students at Humboldt State University. I especially wish to acknowledge the field assistance provided by Sean Simpson who served in a volunteer capacity as did Paul Petros, Patrick and Diane Higgins, and my wife Peggy. Jo Kim, Stephen Judd and Tony Mangrell assisted with the sorting and preliminary identifications of epibenthic and planktonic macrofauna. Terry Strange and Timothy Salamunovich provided valuable taxonomic information on aquatic insects and estuarine crustacea. Finally, I wish to thank Dr.'s David Craigie and Barry Noon, formerly of Humboldt State University, for sharing analytical advice. Douglas Johnson of the United States Fish and Wildlife Service provided computer software for his method of evaluating resource preference. Terry Hofstra of Redwood National Park and James Harrington of the California Department of Fish and Game also provided valuable analytical suggestions. I also wish to acknowledge the support of the Tyee Club of San Francisco.

TABLE OF CONTENTS

TABLE OF CONTENTS (CONTINUED)

APPENDIXES

Page

TABLE OF CONTENTS (CONTINUED)

APPENDIXES (CONTINUED)

TABLE OF CONTENTS (CONTINUED)

APPENDIXES (CONTINUED)

TABLE OF CONTENTS (CONTINUED)

APPENDIXES (CONTINUED)

TABLE OF CONTENTS (CONTINUED)

APPENDIXES (CONTINUED)

LIST OF TABLES

LIST OF FIGURES

FIGURES (CONTINUED)

INTRODUCTION

Estuaries of the Pacific Coast are highly productive and dynamic ecosystems. Cyclic processes of sediment deposition from riverine and oceanic sources form bars that partially or completely close some estuaries. When closed, an estuary is transformed into a coastal lagoon (R.S.K. Barnes 1980). These lagoons become traps for nutrients and detritus from allochtonous and autochthonous sources (Tennore 1977, Reimers 1978, Odum et al. 1979, Barnes 1980, Simenstad 1983). In these systems a pool of organic carbon, derived primarily from detritus, can accumulate behind the sill or sand barrier. A great deal of this organic material is eventually utilized by the benthic and planktonic communities, forming the base of a food web which supports populations of anadromous salmonids (Sibert et al. 1977, Reimers 1978, Healey 1979, Sibert 1979, Naiman and Sibert 1979) (Figure 1).

A variety of life history patterns are displayed by chinook salmon (*Oncorhynchus tshawytscha*) stocks throughout their range and within drainage systems (Gilbert 1913, Reimers 1973, Healey 1982, Kjelson et al. 1982, Simenstad et al. 1982, Allen and Hassler

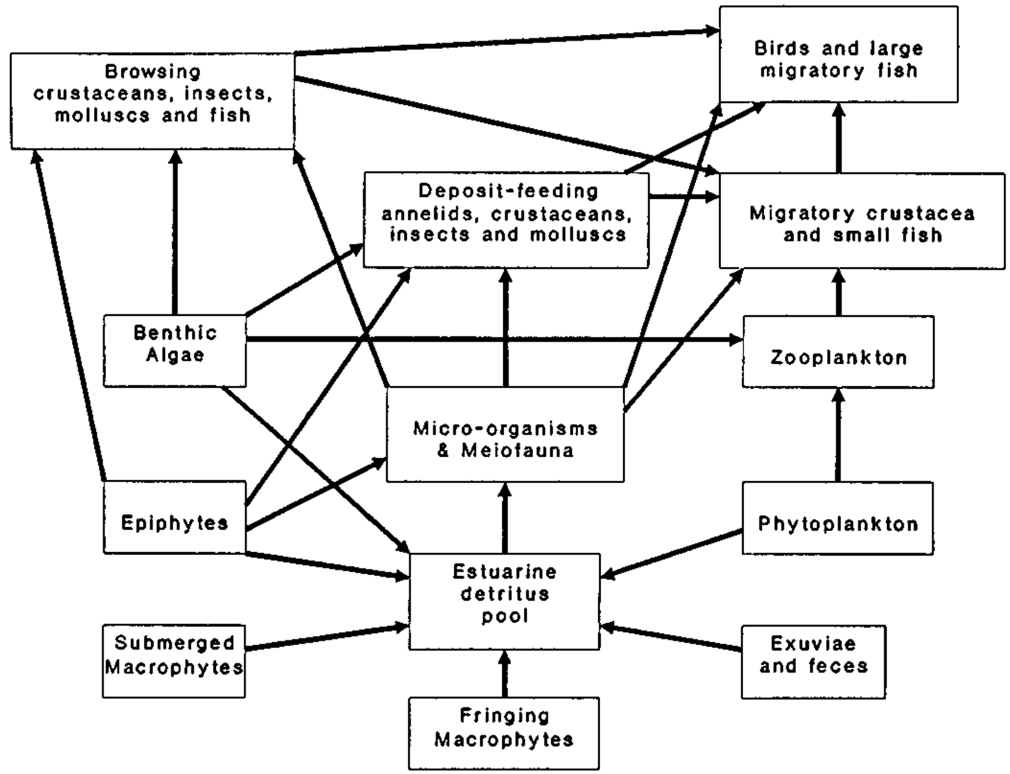


Figure 1. Diagram of a Hypothetical Foodweb of an Estuary or Coastal Lagoon. Arrows Indicate Pathways of Energy in the Form of Organic Carbon. (From R.S.K. Barnes 1980).

1986, Nicholas and Hankin 1988). Variations occur in length of residency in riverine, estuarine and oceanic waters, timing of spawning runs and oceanic distribution.

Chinook salmon demonstrate a greater dependency on estuarine residency than other species of anadromous salmonids (Reimers 1973, Reimers 1978). The length of residency within estuaries and the utilization of estuarine food resources have been documented as important in the growth and survival of outmigrating juvenile chinook salmon (Reimers 1973, Reimers 1978, Reimers et al. 1978, Reimers et al. 1979, Reimers and Concannon 1977, Healey 1980, Healey 1982, Kjelson et al. 1982, Meyers and Horton 1982, Simenstad et al. 1982). Estuaries can provide an environment for productive foraging, physiological transition to oceanic conditions, and refuge from predators (Simenstad et al. 1982). Reimers (1973) concluded that a survival advantage was gained by chinook salmon that remained in the Sixes River estuary throughout the summer over those that outmigrated directly.

The ecology and feeding habits of juvenile chinook in Pacific Coast estuaries have been studied by numerous investigators (Table 1).

Table 1. Studies of the estuarine ecology and feeding habits of juvenile salmonids, listed by drainage.

Drainage	Author
Pescadero, San Gregorio, Waddell, and Pomponio Creeks, California	Smith 1987
Sacramento/San Joaquin, California	Cannon 1982 Kjelson et al. 1982
Mattole River, California	Young 1987 Busby et al. 1988
Redwood Creek, California	Hofstra 1983 McKeon 1985 Larson 1987 Salamunovich 1987
Sixes and Elk Rivers, Oregon	Reimers 1973 Reimers and Concannon 1977 Reimers et al. 1978 Reimers et al. 1979 Reimers and Downey 1982 Nicholas et al. 1984
Yaquina Bay, Oregon	Meyers and Horton 1982
Columbia River, Oregon	Craddock et al. 1976 McCabe et al. 1986
Puget Sound, Washington	Pearce and Meyer 1982 Simenstad et al. 1982
Nanaimo River, British Columbia	Naiman and Sibert 1979 Healey 1979 Naiman and Sibert 1979 Sibert 1979 Healey 1980
Campbell River, British Columbia	Macdonald et al. 1987

Juvenile salmon diets vary considerably between estuaries and habitats within an estuary (Sibert and Kask 1978, Healey 1982, Simenstad and Wissmar 1984, Macdonald et al. 1987, Nicholas and Hankin 1988). Although food organisms are often abundant, there are indications that many of these are available to juvenile chinook only during planktonic larval stages or during diel vertical migrations (Reimers 1973, Reimers et al. 1979, Healey 1980, Healey 1982, Nicholas et al. 1984, Simenstad and Wissmar 1984). Growth and survival of juvenile salmon are influenced and perhaps limited by the availability of epibenthic meiofauna and macrofauna prey items such as: copepods, dipteran larvae and pupae, gammarid amphipods, *Corophium* sp., and mysid shrimp (Sibert et al. 1977, Reimers 1978, Healey 1979, Naiman and Sibert 1979, Reimers et al. 1978, Reimers et al. 1979, Barnes 1980, Cannon 1982, Healey 1982, Kjelson et al. 1982, Simenstad et al. 1982, Beauchamp et al. 1983, Simenstad 1983, Barnes 1984, Nicholas et al. 1984, Allen and Hassler 1986, Grosse and Pauley 1986).

The objectives of this study were to describe the species composition of the epibenthic and planktonic macrofaunal communities and estimate the abundance of potential food organisms for juvenile chinook salmon in the Mattole River estuary/lagoon during the summer and early fall of 1986 and 1987. These data were then compared to the occurrences of prey items observed in the chinook diet to determine food resource preference (Johnson 1980). Inferences about the adequacy of this diet for the growth and survival of juvenile chinook were made. Relationships between changes in diet composition and/or abundance and species assemblage of prey organisms were examined as were potential effects of shifts in the physical and chemical environment of the estuary/lagoon.

STUDY SITE

The Mattole River basin is a 785 square kilometer coastal drainage located in Mendocino and Humboldt Counties, California (Young 1987). The river flows in a northwesterly direction and enters the Pacific Ocean 60 km south of the city of Eureka, California (Figure 2). The 105 km mainstem of the Mattole is joined by 74 tributaries (Barnhart and Young 1985) and is bordered by the King Range National Conservation area to the southwest and the Eel River drainage to the northeast (California Department of Water Resources 1974). Flow in the Mattole is extremely variable through the year, ranging historically from 0.6-2560.0 cubic meters per second (cms) at the Petrolia gauging station (California Department of Water Resources 1973). The climate of this region is described as humid mesothermal, with heavy winter rains and coastal fog in the summer (California Department of Water Resources 1973).

Anadromous fishery resources in the Mattole River basin have been severely impacted by poor land use practices (California Department of Fish and Game 1965, Barnhart and Young 1985, Peterson 1985, Young

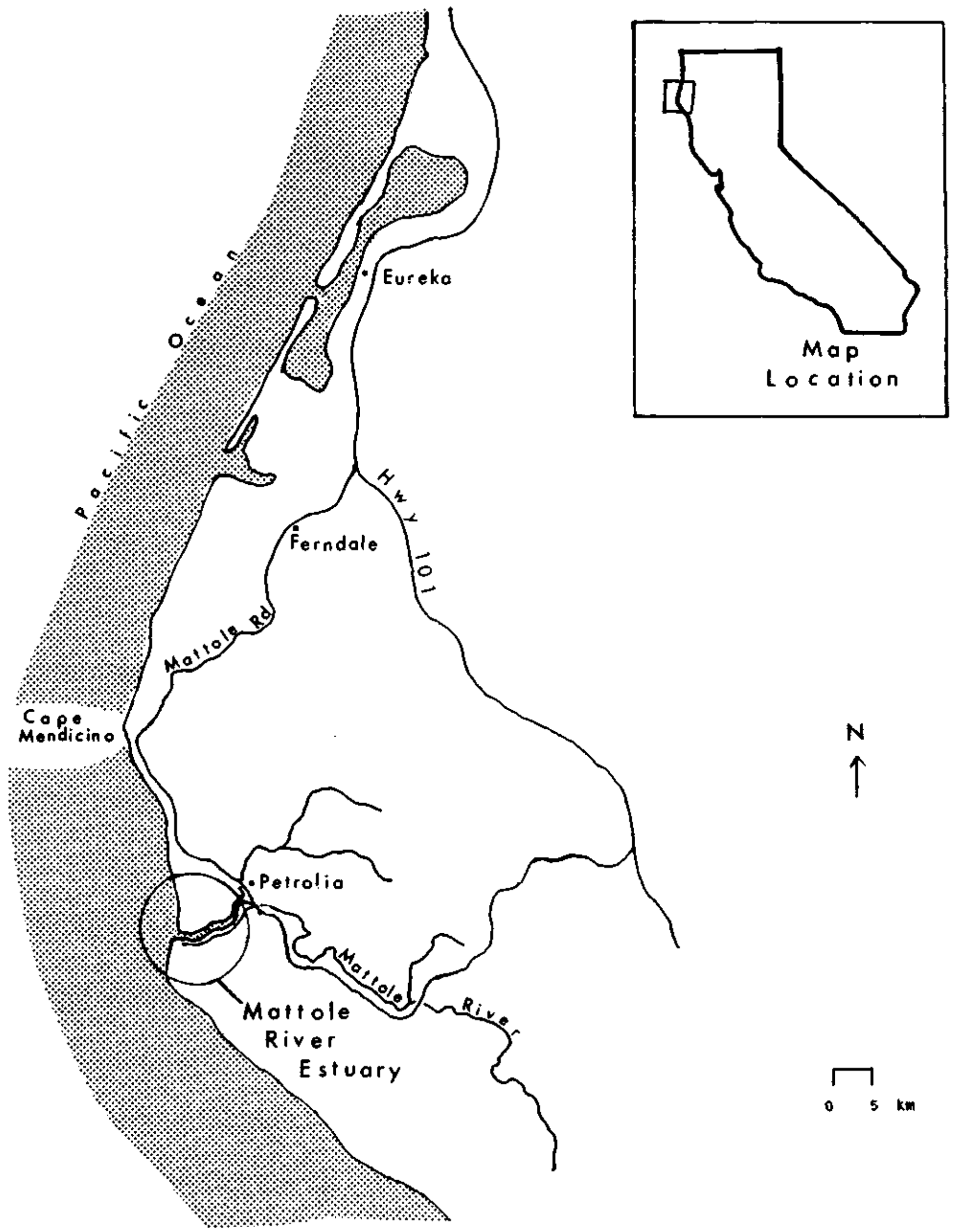


Figure 2. Location Map of the Mattole River Estuary/Lagoon, Humboldt County, California.

1987, Busby et al. 1988). Logged areas were not reforested and in many areas grazing land has taken their place. The disturbed land is geologically unstable and susceptible to slumping, erosion, and landslides. Deposition of sediments has caused significant reduction in salmonid spawning and rearing habitat. Impacts extend to the estuary in the form of an aggraded river channel and lack of riparian vegetation along the south bank due to grazing cattle.

In the early summer, a combination of sediment deposition from onshore ocean currents, constructive wave action, and decreased river flows, cause a sandbar to form which closes the river mouth (Young 1987). This physical process is described thoroughly by Barnes (1980). Through this process the estuary is transformed into a small coastal lagoon (Pritchard 1967, Barnes 1980). Similar processes have been documented in Humboldt County at Big Lagoon (Joseph 1958) and Redwood Creek (Hofstra 1983).

As the river mouth is closed by the sand bar, river water floods an area of approximately three hectares (Busby et al. 1988). Riparian vegetation, gravel bars and boulders are inundated by this flooding which creates habitat for birds, fish and other aquatic organisms. Shortly after formation of the lagoon, dilution by incoming river water and wind driven mixing cause the system to become essentially freshwater. Seawater occasionally washes over the berm during high tide periods in the dry summer months (California Department of Water Resources 1973). Juvenile salmonids migrating to the ocean are trapped in the lagoon until high river flows and wave action breach the berm in early fall (Young 1987).

Several fish species have been collected in the lagoon including chinook salmon, coho salmon (*O. kisutch*), steelhead (*O. mykiss*), and others (Busby et al. 1988). Potential fish predators using the lagoon are river otter (*Lutra canadensis*), osprey (*Pandion haliaetus*), gulls (*Larus* sp.), terns (*Sterna* sp.), herons (Ardeidae), cormorants (*Phalacrocorax* sp.), mergansers (*Mergus* sp.), loons (*Gavia* sp.), grebes (Podicipedidae), and brown pelican (*Pelecanus occidentalis*) (Busby et al. 1988).

The substrate of the lower lagoon is comprised predominantly of sand with larger rocks and boulders located along the eastern shore (Young 1987, Busby et al. 1988). Strong northwesterly winds, characteristic of this area, mix the water column causing the sandy bottom of the lower lagoon to become relatively flat. Substrate in the upper lagoon is composed predominantly of gravel with some cobbles, stones, and boulders which is more characteristic of riverine systems (Bottom et al. 1979, Cowardin et al. 1979).

A mat of organic material covers the bottom by mid summer and filamentous algae grow in abundance. Numerous aquatic invertebrates inhabit this algal covering.

Depths within the lagoon vary depending on winter scouring patterns and water level which fluctuates considerably (Barnhart and Busby 1986, Busby et al. 1988). The riparian zone along the north side of the upper lagoon provides overhanging and submerged vegetation used by several species of aquatic invertebrates, fish and wildlife. A complete inventory of the natural resources of the Mattole River estuary/lagoon including habitat types, vegetation, fish and wildlife can be found in Busby et al. (1988).

MATERIALS AND METHODS

Sampling, observations, and other data collections were conducted from June through October 1986 and late May through November 1987. Epibenthic and planktonic macrofauna were collected at two stations: one each in the upper and lower reaches of the estuary/lagoon (Figure 3). Juvenile chinook salmon taken for stomach analysis were collected at four different locations (Figure 3). Keys and other references used to identify the organisms in epibenthic, plankton and juvenile chinook stomach samples were Smith and Carlton (1975), Borror et al. (1981), R.D. Barnes (1980), and Merritt and Cummings (1985). All organisms retained on 0.5mm mesh screen after thorough washing are referred to as macrofauna.

Epibenthic Macrofauna

A 0.01 m^2 (10x10 cm opening) Ekman grab was used to collect epibenthic organisms in 1986. Three grabs were taken monthly at each station. The contents were then combined, washed on a sieve and preserved in 70% ethanol. The samples were later sorted for identification and enumeration.

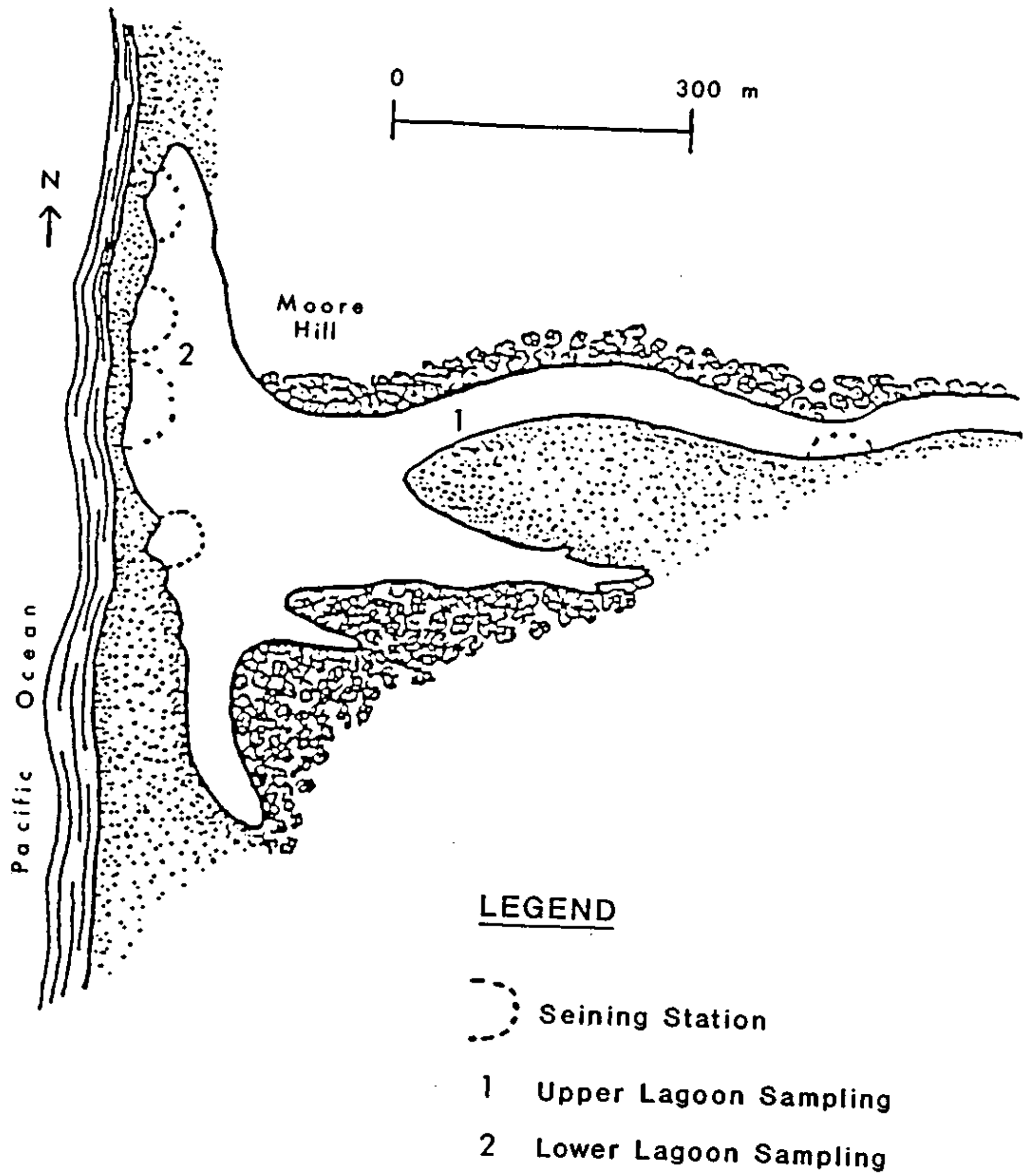


Figure 3. Map of the Mattole Estuary\Lagoon, Showing Epibenthic, Zooplankton, and Juvenile Chinook Salmon Sampling Sites.

A preliminary investigation was conducted in 1986 to estimate densities of epibenthic species and evaluate the effectiveness of an in-place "bucket type" substrate sampling system. Ten 21.5 x 16.5 x 8.0 cm (0.04 m^2 surface area) rectangular plastic food storage containers were filled with representative bottom material and buried with the rims exposed at each station by SCUBA divers. A 5.0 cm diameter white styrofoam sphere was attached to each container with a 50 cm strand of monofilament fishing line to assist in finding the containers. A distance of 50 cm separated the samplers which were buried in two rows of five, in the center of the stream channel. A period of 30 days was allowed for colonization. All remaining containers were then removed. The removal procedure required divers to snap lids on samplers and swim them to the surface. Contents of substrate samplers were washed through a series of bucket sieves. All organisms retained on the 0.5mm mesh screen were then preserved in 70% ethanol. The samples were later sorted, identified to the lowest taxa possible, and enumerated.

Sixteen containers were placed at each station in a 4x4 grid on July 1, 1987. A distance of 50 cm separated each container. A row (four containers) perpendicular to the direction of stream flow was removed at approximately 30 day intervals. Samples were processed in the same manner as in 1986 except that preservation was in a 5% buffered formalin solution instead of ethanol. In addition, dry weight biomass was estimated for all taxa. Selected organisms were dried in tared weighing pans at 35^{o} C for 24 hours. The dried material was then allowed to cool for two hours in a desiccator before being weighed to the nearest microgram.

Planktonic Macrofauna

A conical 0.333 mm mesh plankton net with a diameter of 0.5 m, length of 2 m, and a removable PVC reinforced cod end was used to collect zooplankton along two 300 m transects in 1986 and 1987 (Figure 3). At the lower transect, sampling occurred at mid-depth except during net deployment and retrieval. Nearly the entire water column was sampled along the upper transect due to shallow depth.

Zooplankton samples were collected biweekly during daylight hours in 1986. Immediately after collection, the plankton was preserved in 70% ethanol. These samples were later sieved, sorted, identified to the lowest taxa possible, and enumerated.

Light gauge cord was used to suspend a General Oceanics flowmeter in the center of the net opening for collections in 1987. The flowmeter was calibrated by conducting 10 test tows of 20 meters length in a swimming pool at a constant speed of one meter per second. The beginning and end readings were recorded and the number of revolutions per tow determined. A correlation between the number of revolutions and distance traveled was established (mean number flowmeter revolutions/meter). A towing speed of approximately one meter per second was maintained in the field by towing the net along the 300 m transects for five minutes.

Zooplankton sampling was conducted at monthly intervals in 1987. Samples were collected during daylight hours in the same manner as in 1986. In addition, nighttime sampling was conducted along each transect around midnight. All 1987 samples were treated in the same manner as those collected in 1986, except that preservation was in a 5% buffered formalin solution. In addition, dry weights were obtained for each taxonomic group using the same techniques as for 1987 epibenthic macrofauna.

Food Habit Analysis

A 54.7 m x 4.8 m beach seine of 6.4 mm mesh was set at four sites in the lower lagoon to collect juvenile chinook for food habit analyses in 1986 and 1987 (Figure 3). Collections occurred biweekly in 1986 and monthly in 1987. An electrofishing boat was used in September 1987 to sample along the 300 m plankton transect in the upper lagoon.

In all collections, captured fish were transferred to live pens, anesthetized with MS-222 and sorted by species. Juvenile chinook were counted and measured to the nearest 1.0 mm fork length. When available, ten chinook were sacrificed for stomach analysis and weighed to the nearest 0.1 gram with a triple beam balance. These fish were then slit ventrally and preserved in a 10% buffered formalin solution.

Stomachs from individual juvenile chinook were removed and placed in a Petri dish containing water. The stomachs were then opened with a razor blade. All contents were gently rinsed out with a squeeze bottle and carefully separated with forceps and a probe. A dissecting microscope was used to identify contents and sort them into respective food types. Food items were then grouped by taxa and enumerated. Volumes of each prey type were measured with a graduated centrifuge tube to the nearest 0.05 ml.

Statistical Methods

Compilation of data and basic descriptive statistics (sum, percentage, mean, standard deviation, standard error) were preformed using the spreadsheet program Lotus 1-2-3 version 2.01 (Lotus Development Corporation 1987). More complex statistical procedures (95% Confidence

Interval of mean, Mann-Whitney U test, Bartlett's Test, one, two and three-way ANOVA, Kruskal-Wallis test, Two-way nonparametric ANOVA, parametric and nonparametric Tukey's multiple comparison tests) were accomplished using the programs Minitab (Ryan et al. 1985), and Systat (Wilkinson 1988). Food resource preferences of juvenile chinook salmon were determined using the program PREFER (Johnson 1980). Descriptions of all analytical procedures used can be found in Johnson (1980) and Zar (1984).

Epibenthic Macrofauna

Ekman grab data collected in 1986 were used primarily to identify the representative organisms of the epibenthic community. The total numbers of individuals of each species collected in each grab set were tabulated to examine their catch per unit effort and relative abundances. The Mann-Whitney U statistic was used to test for differences between the total numbers of organisms collected at the upper and lower sites over the entire sampling period. Confidence intervals of 95% were calculated for the means of each taxonomic category at each site over the entire study period. Overlapping ranges were considered to be not significant.

Data from the 1986 bucket type substrate sampler pilot study were used to assess the effectiveness of this sampling system. Variance in the numbers of individuals collected in the containers was used to estimate the sample size needed for the 1987 epibenthic survey by the methods of Harris et al. (1948) as described by Zar (1984 pages 108-110) and their precision as a sampling unit.

Mean densities were estimated for all organisms collected as a total and for each individual taxon based on the surface area of the substrate sampler. The Mann-Whitney U statistic was used to test differences in the number of species collected by the Ekman grab and the bucket type artificial substrate samplers.

Densities and biomasses were calculated for each taxonomic group collected during each sampling date at each sampling site for the 1987 study period. This was accomplished by dividing the number or dry weight by the surface area of the sampler. The 95% confidence intervals around the means were computed for the numeric and biomass values of each taxonomic group. Overlapping ranges were considered non-significant. Two-way analysis of variance (Zar 1984) was used to test for differences between sampling dates and sites for the overall (all taxa) numbers and biomasses. Residuals were plotted to visually inspect for homogeneity of variance. A square root transformation was necessary for the biomass estimates to meet the required assumptions of the analysis. Bartlett's test (Zar 1984) was used to confirm that the data met the assumptions. The Tukey multiple comparison test for unequal sample size (Zar 1984) was used to determine where specific differences existed.

Planktonic Macrofauna

Data from plankton samples collected in 1986 were used to identify the components of the zooplankton community and determine their relative abundances. Numerical data were analyzed in the same manner as the epibenthic macrofauna collected by Ekman grab from the same year.

Zooplankton samples collected in 1987 were used to quantify the abundances and biomasses of potential food items for juvenile chinook salmon. Differences in concentrations, biomass and number of taxa collected between sampling dates, sites and diel periods were also examined.

Zooplankton concentrations and biomasses were calculated for each taxonomic group collected at each site for each sampling date and diel period. This was accomplished by dividing the number or dry weight by the volume filtered. Calculations of 95% confidence intervals were made for the mean zooplankton concentrations and biomasses. Overlapping ranges were considered not significant. Three factor analysis of variance for single observations (Zar 1984) was used to test for differences in overall zooplankton concentrations and number of taxa collected between the sampling dates, sites and diel periods. Concentration data required a base 10 logarithmic transformation to satisfy test assumptions. Nonparametric three way analysis of variance was used to test for differences in the biomass data. Nonparametric multiple comparison testing was used in the latter case.

Food Habits of Juvenile Chinook Salmon

Means, 95% confidence intervals, and percentages by number, frequency of occurrence, and volume were computed for each taxa identified in juvenile chinook stomachs for each sampling date. Taxa with overlapping 95% confidence interval ranges around the means were considered as not significantly different.

The Kruskal-Wallis test (Zar 1984) was used to test for differences in overall numbers, volumes and numbers of prey types consumed between sampling dates. Nonparametric Tukey type multiple comparison testing was used after significant Kruskal-Wallis tests to locate specific differences.

Preference (selection) of certain prey categories were determined using the method of Johnson (1980). This is a non-parametric procedure which can be used to test for significance between the difference in ranks of prey components by usage and availability. Lower estuary/lagoon daytime abundances of zooplankton were used as the availability components in both years with the exception of September, 1987 when fish were collected at the upper site at night. Usage components were the occurrences of prey types in the diet. Analyses were conducted for each individual sampling date and for the two study periods overall. An additional preference analysis was conducted using zooplankton biomass as the availability component and stomach content volumetric data as the usage component from 1987 data.

Two-way nonparametric analysis of variance was used to test for differences between overall numbers, volumes and numbers of prey types consumed on three selected sampling dates in 1986 and 1987. These dates were 27 June, 24 July, 29 August 1986, and 22 June, 21 July, and 23 August 1987.

RESULTS

A complete phylogenetic list of taxa identified from epibenthic and plankton samples collected during the 1986 and 1987 study periods is given in Appendix A. This updates the partial list given in Busby et al. (1988).

Epibenthic Macrofauna

Lower Site 1986

Ekman grab samples taken from the lower estuary/lagoon in 1986 contained large numbers of amphipods (Figure 4)(Appendix B). *Corophium spinicorne* was collected the most frequently. A few *Eogammarus confervicolus* were also collected.

In late June, larvae of the trichopteran *Gumaga griseus* were second most abundant in the catch behind amphipoda, followed by Oligochaetea and Platyhelminthes. In early July, aquatic mites (subphylum Chelicerata, subclass Hydracarina), larvae of Trichoptera and Diptera, and the isopod *Gnorimosphaeroma oregoniensis* followed Amphipoda in number of individuals collected. The catch of Isopoda rose sharply in late July. Larvae of Coleoptera, Diptera, Ephemeroptera, and Trichoptera were also

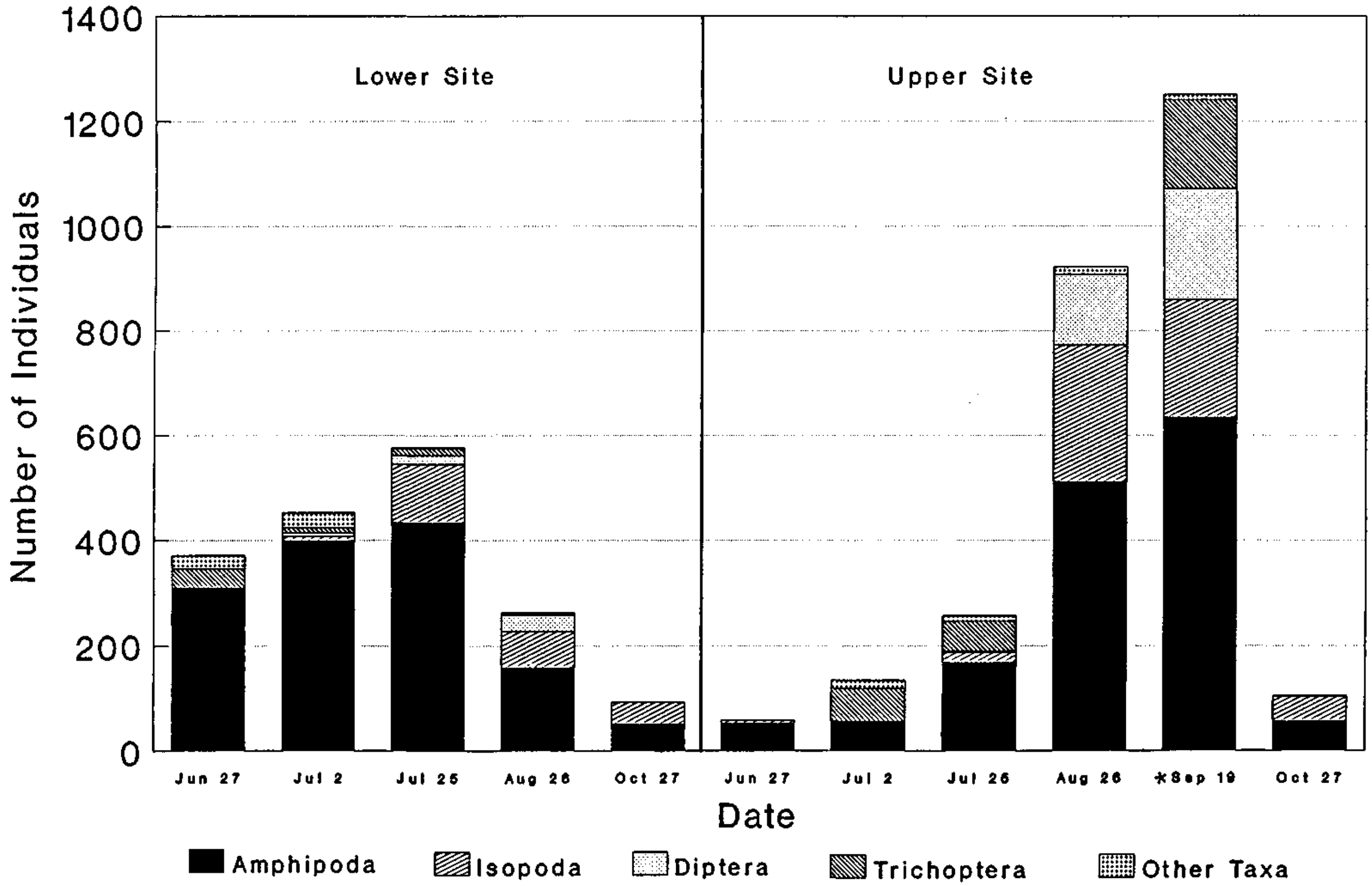


Figure 4. Catch per Unit Effort of Epibenthic Organisms in 0.02 m^2 Ekman Grab, Lower and Upper Mattole Estuary/Lagoon 1986. * = 0.04 m^2 bucket type substrate sampler pilot study.

collected. In late August, numbers of Amphipoda and Isopoda declined but they continued to dominate the samples taken. The number of Diptera larvae collected nearly doubled. Cyclopoid copepods (*Cyclops* sp.), the mysid *Neomysis mercedis* and Hydracarina were also present. Sampling in September was not conducted due to unusually high river flows. Only Amphipoda and Isopoda were collected in October and fewer individuals were present. The catch of Amphipoda was significantly greater than all other taxa throughout the sampling period ($p < 0.001$). No significant differences in numbers collected were found between any other taxa.

Upper Site 1986

Ekman grab samples collected in the upper lagoon also contained large numbers of Amphipoda but they comprised a smaller percentage of the total than in the lower lagoon (Figure 4) (Appendix C). In late June, Amphipoda and a few Isopoda were collected. Similar numbers of Trichoptera larvae and Amphipoda were collected in early July. Isopoda and the larvae of Diptera, Ephemeroptera (several species) and Megaloptera (*Sialis* sp.), were also present. In late July, numbers of Amphipoda increased. Trichoptera larvae were collected in numbers about equal to those of early July. The number of Isopoda increased moderately. Larvae of

Ephemeroptera and Diptera were also collected. Numbers of Amphipoda, Isopoda and Diptera larvae collected increased dramatically in late August. Mysidacea and Ephemeroptera larvae were also collected as was a single individual of the hemipteran, *Pelocris* sp.. By late October, numbers of Amphipoda and Isopoda had greatly declined. A single mysid was also collected. Although amphipods occurred most frequently in the samples, differences between the total numbers of each taxa collected in the 1986 upper lagoon Ekman grab samples were barely significant ($p = 0.05$). Amphipoda, Isopoda and Diptera larvae were most abundant with all other taxa following. No significant differences were found between the total numbers of organisms collected at the upper and lower estuary/lagoon sampling sites over the 1986 study period.

Samples collected in the lagoon during September 1986 were obtained during a pilot study designed to test the effectiveness of a bucket type substrate sampler. Of the 20 containers installed, only nine were recovered. All containers were recovered from the upper lagoon but one did not seal properly so its contents were discarded.

Amphipoda accounted for nearly 50% of the organisms collected and were the most abundant taxa (Figure 4) (Appendix D). Isopoda and the larvae of Diptera and Trichoptera were second most abundant. No significant differences in abundance were found among the remaining taxa. Estimated mean densities for the total of all organisms collected and each individual taxa are given in Appendix D. The overall estimated density for all taxa combined was 38,763 ± 5,654 SD individuals per square meter. Further calculations revealed a probability of 0.10 that the 95% confidence interval was no wider than 280 organisms for the eight containers. Based on this information and the time required to process the contents of the containers, this was considered to be an adequate sample size. It was also determined that the bucket type substrate sampler collected more species than the Ekman grab ($p < 0.004$).

Lower Site 1987

Bucket type samplers retrieved from the lower lagoon in July, 1987 contained mostly Trichoptera larvae (Figure 5) (Appendix E). A few Amphipoda and other taxa including diptera larvae were also collected. Differences between the taxa, however, were not significant. August samples were dominated by Amphipoda ($p < 0.05$) (Appendix F). Isopoda and all

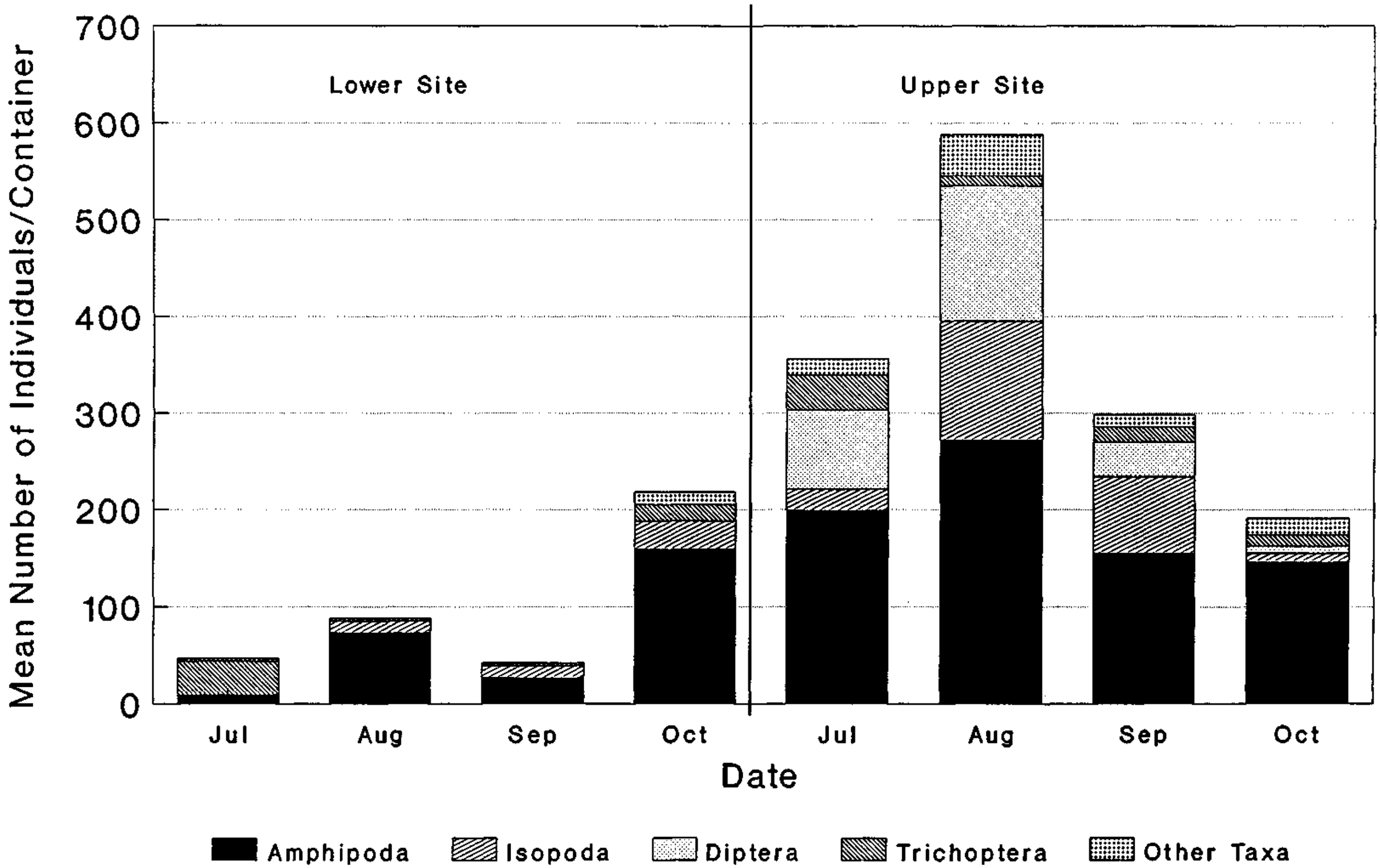


Figure 5. Mean Numbers of Epibenthic (Oligochaeta omitted) Organisms Collected in 0.04 m^2 Bucket Type Substrate Samplers, Lower and Upper Mattole Lagoon 1987.

other taxa collected followed. These included small numbers of Trichoptera and Diptera larvae, Nematoda and Oligochaeta. The abundances of all taxa declined by over 50% in September (Appendix G). Amphipoda and Isopoda were the most abundant. Isopoda, however, were not significantly more abundant than other taxa collected which included Trichoptera and Diptera larvae, Coleoptera and Platyhelminthes. In October, the occurrence of all taxa increased dramatically (Appendix H). Amphipoda were again most abundant ($p < 0.05$). All other taxa followed. These included Isopoda, Trichoptera larvae, and Oligochaeta.

No significant differences were detected between the biomasses of taxa collected in the lower lagoon in July. Trichoptera larvae, however, had the largest mean value and accounted for 82% of the total dry weight biomass (Figure 6) (Appendix E). Amphipods comprised 13% of the total and Diptera larvae 3%. Overall biomass increased in August (Appendix F). Amphipods (73%) contributed the most biomass followed secondly by all other taxa which included Isopods (22%) and Trichoptera larvae (3%). Similar overall biomass was estimated in September (Appendix G). No significant differences were found between any taxa. Amphipods (66.5%) exhibited the largest mean value followed by Isopods (26.5%) and

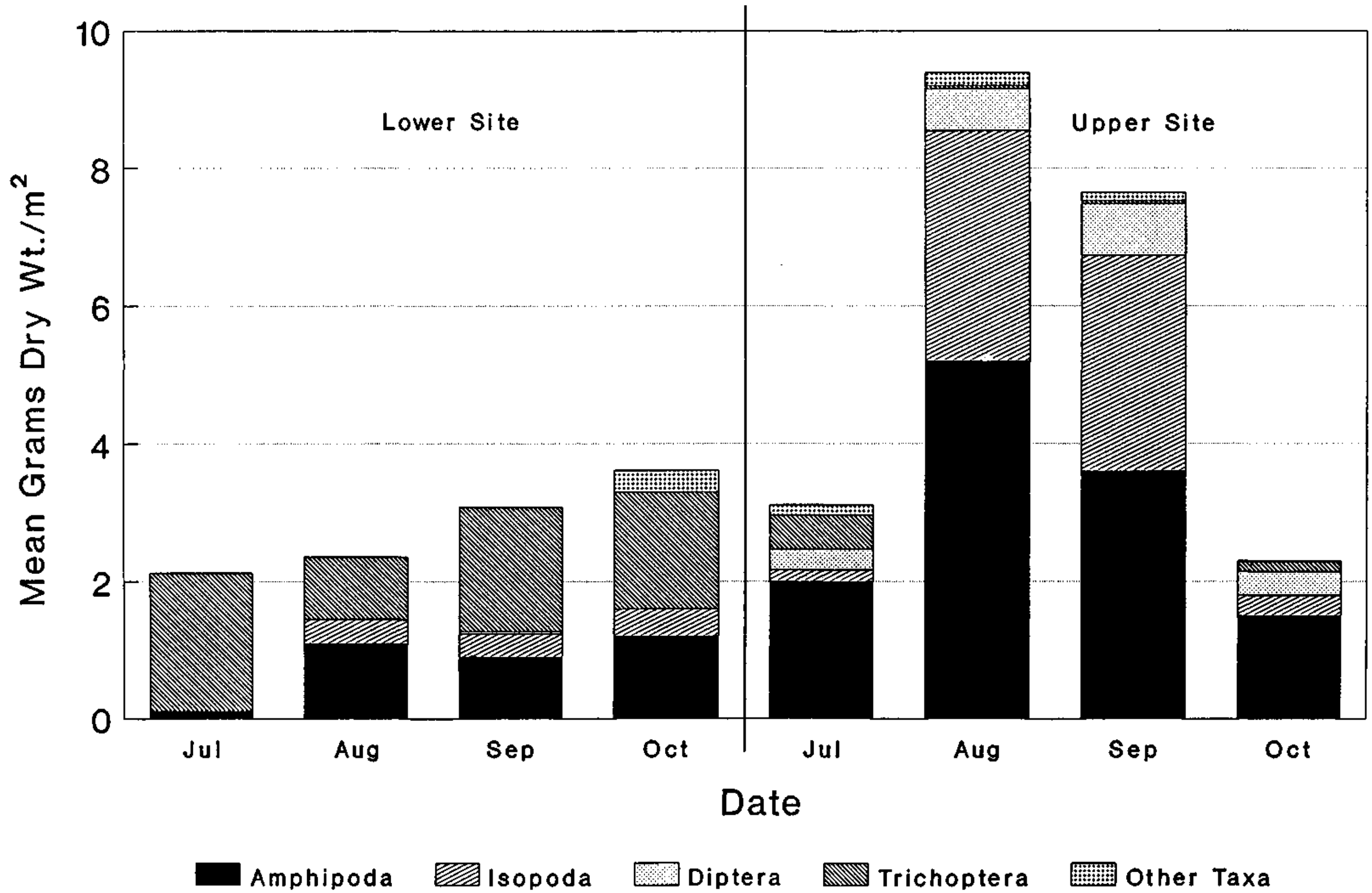


Figure 6. Mean Biomasses of Epibenthic Organisms (Oligochaeta omitted) Collected in $0.04\ m^2$ Bucket Type Substrate Samplers, Lower and Upper Mattole Lagoon 1987.

Trichoptera larvae(4%). Overall biomass increased in October (Appendix H). Biomass of Amphipoda (58%) was significantly greater than all other taxonomic groups which included isopods (19.5%), threespine stickleback (13.1%) and Trichoptera larvae (7%) ($p = 0.05$).

Upper Site 1987

Amphipods were clearly the most abundant taxa collected during upper lagoon sampling in July ($p < 0.05$) (Figure 5) (Appendix I). All other taxa which included Diptera and Trichoptera larvae, Isopoda and Hydracarina followed. Overall numbers of organisms increased sharply in August (Appendix J). Numbers of amphipods collected were significantly greater than isopods and Diptera larvae which followed ($p = 0.05$). Numerous other taxa were also collected including nematodes, Trichoptera larvae, oligochaetes and Hydracarina which followed in abundance. Abundances of all taxa declined during September (Appendix K). Amphipods were most numerous followed by isopods which were significantly greater than all other taxa in abundance except Diptera larvae ($p < 0.05$). Other taxa collected included Trichoptera larvae, Nematoda and larvae of the plecopteran *Capnia* sp.. Numbers of most taxa collected declined during October, except Amphipoda (Appendix L). Extremely large numbers of tubificid oligochaetes were also present. Oligochaeta occurred in numbers significantly greater than all taxa except amphipoda ($p < 0.05$). It was necessary to omit the Oligochaeta from Figure 5 to prevent exclusion of the other taxa.

Amphipods (43.5%) and Trichoptera larvae (44%) were the principal components of the estimated biomass during July in the upper lagoon ($p < 0.05$) (Figure 6). The remaining taxonomic groups followed. These included Diptera larvae (6.5%) and isopods (3.5%) (Appendix I). Overall biomass increased in August with amphipods comprising a significant majority of the total (50%) ($p < 0.05$) (Appendix J). Isopods ranked second in biomass (32.5%) followed by the remaining taxa which included Trichoptera (9%) and Diptera larvae (6%). Overall biomass in September was similar to that estimated in August (Appendix K). Amphipoda (38%) and Isopoda (33%) contributed nearly equally to the biomass and were followed by Trichoptera (19.5%). Differences between the biomasses of Isopoda and Trichoptera larvae were not statistically significant. Diptera larvae ranked third in biomass and were followed by the remaining taxa. A great overall increase of biomass occurred in October (Appendix L). Oligochaetes comprised the majority (76%) followed by Trichoptera (10.5%), Amphipoda (9%), Diptera larvae (2%) and Isopoda (2%). The biomass of Oligochaeta was significantly greater than that of Isopoda, Coleoptera, and Diptera larvae but not Amphipoda and Trichoptera ($p < 0.05$).

Overall Results from 1987

Overall mean numbers and densities of epibenthic organisms were significantly higher in the upper estuary/lagoon ($p < 0.001$). October was the month of highest abundance at the lower site. Numbers on all sampling dates at the upper site were greater than for July, August and September at the lower site. No significant differences were found between sampling dates at the upper site. No interaction between sampling sites and dates occurred.

Overall mean biomasses of epibenthic organisms were also significantly larger in the upper estuary/lagoon ($p < 0.001$). Differences in mean biomass between sampling dates were barely significant ($p = 0.05$). No differences were detected between sampling dates at each individual site but August, September and October biomasses in the upper estuary/lagoon were greater than any in the lower.

Planktonic Macrofauna

Lower Site 1986

Very few planktonic organisms were collected in the lower estuary in June, 1986 (Figure 7) (Appendix M). Hydracarina were the most numerous followed by Trichoptera larvae. Overall numbers increased in early July and the catch was again dominated by Hydracarina. Adult Coleoptera, Amphipoda, Diptera larvae and Isopoda were also collected. A large increase in overall numbers occurred in late July. Amphipoda were by far the most abundant followed by followed by Oligochaeta and mysidacea. Hydracarina, Diptera larvae, Ostracoda and Isopoda were also collected.

Numbers of organisms collected decreased by nearly 50% in early August. Mysidacea were most abundant followed by Amphipoda. Hydracarina, Diptera larvae, Oligochaeta, threespine stickleback larvae, Isopoda, and terrestrial insects were also collected. A substantial increase in overall numbers was seen in late August. Amphipoda were most abundant by a great margin followed by nearly equal numbers of Mysidacea

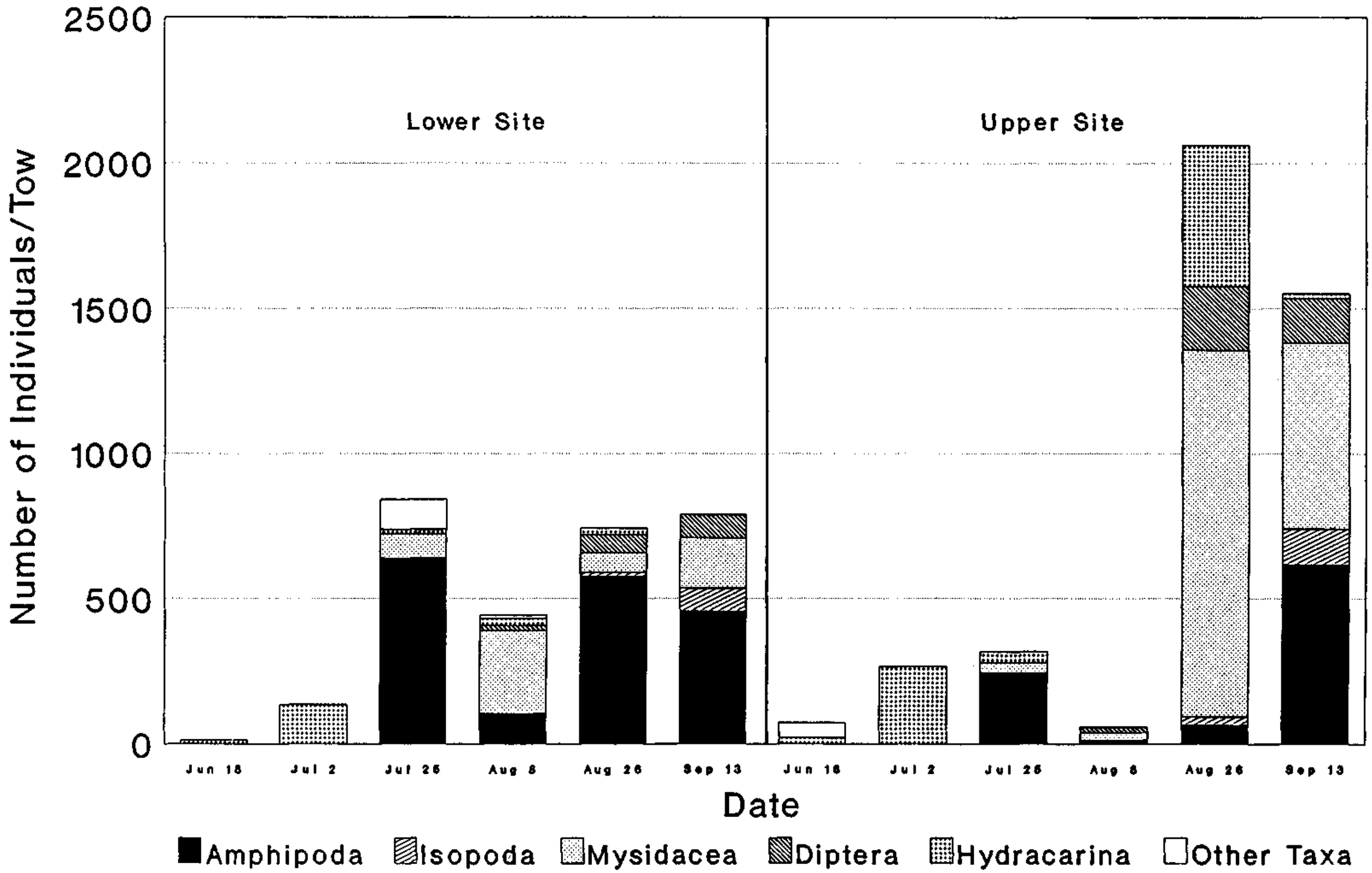


Figure 7. Catch per Unit Effort of Planktonic Organisms in 0.5m, 333µ Mesh Plankton Net, Lower and Upper Mattole Estuary/Lagoon 1986.

and Diptera larvae. Isopoda, Hemiptera, threespine stickleback larvae and terrestrial insects were also collected. Similar overall numbers of organisms were collected in September. Amphipoda were again the most abundant by a substantial margin followed by Mysidacea. Diptera larvae and Isopoda occurred in nearly equal numbers. Hydracarina and threespine stickleback larvae were also collected.

Amphipoda were collected in greater numbers than all other taxa in the lower estuary/lagoon over the entire 1986 study period ($p < 0.05$). No significant differences were detected between any other taxa.

Upper Site 1986

Plankton samples collected in June at the upper site contained mostly Trichoptera larvae (Figure 7) (Appendix N). Hydracarina, Mysidacea, Amphipoda, Isopoda and prickly sculpin (*Cottus asper*) larvae were also collected. Overall numbers of organisms were greater in early July. Hydracarina dominated the sample by a great margin followed by adult Coleoptera, larval and adult Diptera, Trichoptera larvae (*Oxyethria* sp. and *Ithythricia* sp.), and terrestrial insects. Similar numbers of organisms were collected in late July. Amphipoda were by far the most abundant followed by Mysidacea, Diptera and Coleoptera larvae and adults, Hemiptera, Isopoda, Odonata (*Hetaerina* sp.), and threespine stickleback larvae.

Overall numbers of zooplankton declined substantially in early August. Mysidacea and Diptera larvae occurred in similar numbers followed by Amphipoda, Hydracarina, and terrestrial insects. A remarkable increase in zooplankton numbers was seen in late August. Mysidacea dominated the sample by a great margin followed by Hydracarina, and Diptera larvae. Amphipoda, Isopoda, Copepoda, Hemiptera and terrestrial insects were also collected. Numbers declined marginally in September. Mysidacea and Amphipoda were the most abundant and were collected in similar numbers. Diptera larvae and Isopoda occurred less frequently with similar numbers. Hemiptera and Copepoda were also collected.

Terrestrial insects collected throughout the 1986 zooplankton sampling included Hymenoptera, Coleoptera, Arachnida, and Hemiptera (Homoptera, Cicadellidae - leaf hoppers). Mysidacea occurred in significantly greater numbers than all other taxa over the entire 1986 sampling period with the exception of Amphipoda, Diptera, and Hydracarina ($p < 0.05$). No significant differences were detected between any other taxa. There was no significant difference between overall numbers of organisms or species collected at the upper and lower sites.

Lower Site 1987

Diptera larvae, aquatic Coleoptera and Hydracarina were collected in similar numbers during daytime sampling at the lower site in July (Figure 8) (Appendix O). Trichoptera larvae, Copepoda, Isopoda, Oligochaetes and terrestrial insects were also collected. Greater numbers of organisms were collected in August. Copepoda comprised the majority followed by Hydracarina, Diptera larvae, Amphipoda and Coleoptera.

Similar overall numbers of organisms were collected in September. Diptera larvae were the most abundant followed by Amphipoda. Fewer individuals of several other taxa were also collected. A great increase in numbers of organisms was observed in October. Ostracoda occurred most frequently by a great margin over Hydracarina. Copepoda (Figure 9) and Amphipoda were among the other taxa collected. No significant differences in concentration were found between the taxa the overall combined study period (all sampling dates).

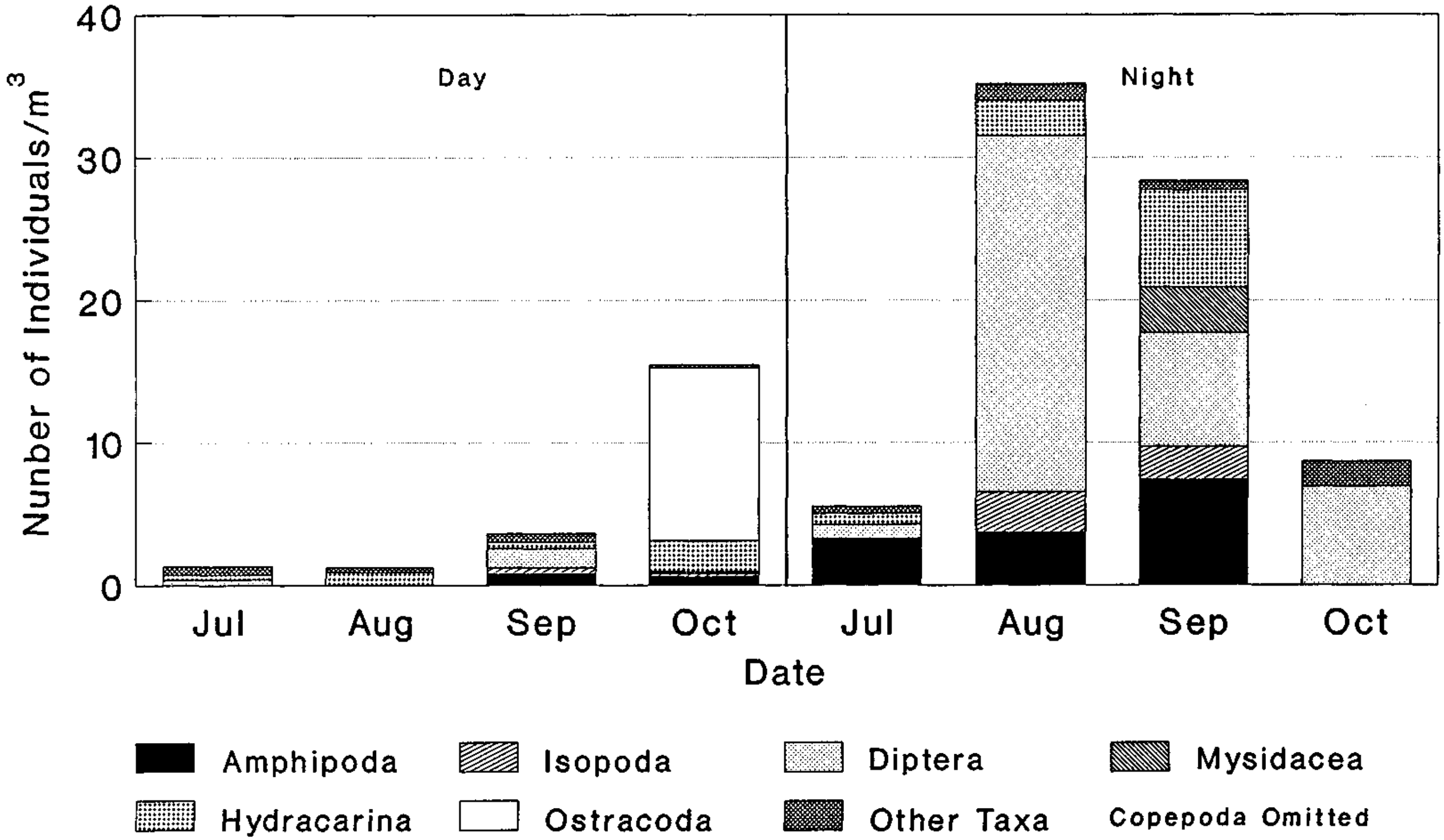


Figure 8. Concentrations of Planktonic Organisms in 0.5m, 333µ Mesh Plankton Net Tows, Lower Mattole Lagoon 1987 Day and Night.

Trichoptera larvae and Coleoptera comprised the majority of the plankton biomass in July (Figure 10) (Appendix P). Overall biomass declined in August of which nearly all was Hydracarina. A large increase was observed in September. Mysidacea contributed the largest amount of biomass followed by Amphipoda, Isopoda and Hydracarina. Overall biomass increased again in October. Isopoda, Ostracoda and Hydracarina comprised similar fractions followed by Amphipoda. No significant differences in biomass were found between the taxa for the overall combined study period (all sampling dates).

The nighttime sample collected in July contained mostly amphipoda (Figure 8) (Appendix Q). Diptera larvae, Copepoda, and Hydracarina were among other taxa collected. A great increase in plankton concentration was observed in August. Copepoda (Figure 9) comprised the majority by a great margin. Diptera larvae, Amphipoda, Isopoda and Hydracarina were also collected.

Numbers of Copepoda increased greatly again in September. Amphipoda increased modestly while Isopoda remained at similar concentrations and Diptera larvae declined from the previous month. A massive decline occurred during October (Figure 8). Copepoda again dominated the sample (Figure 9).

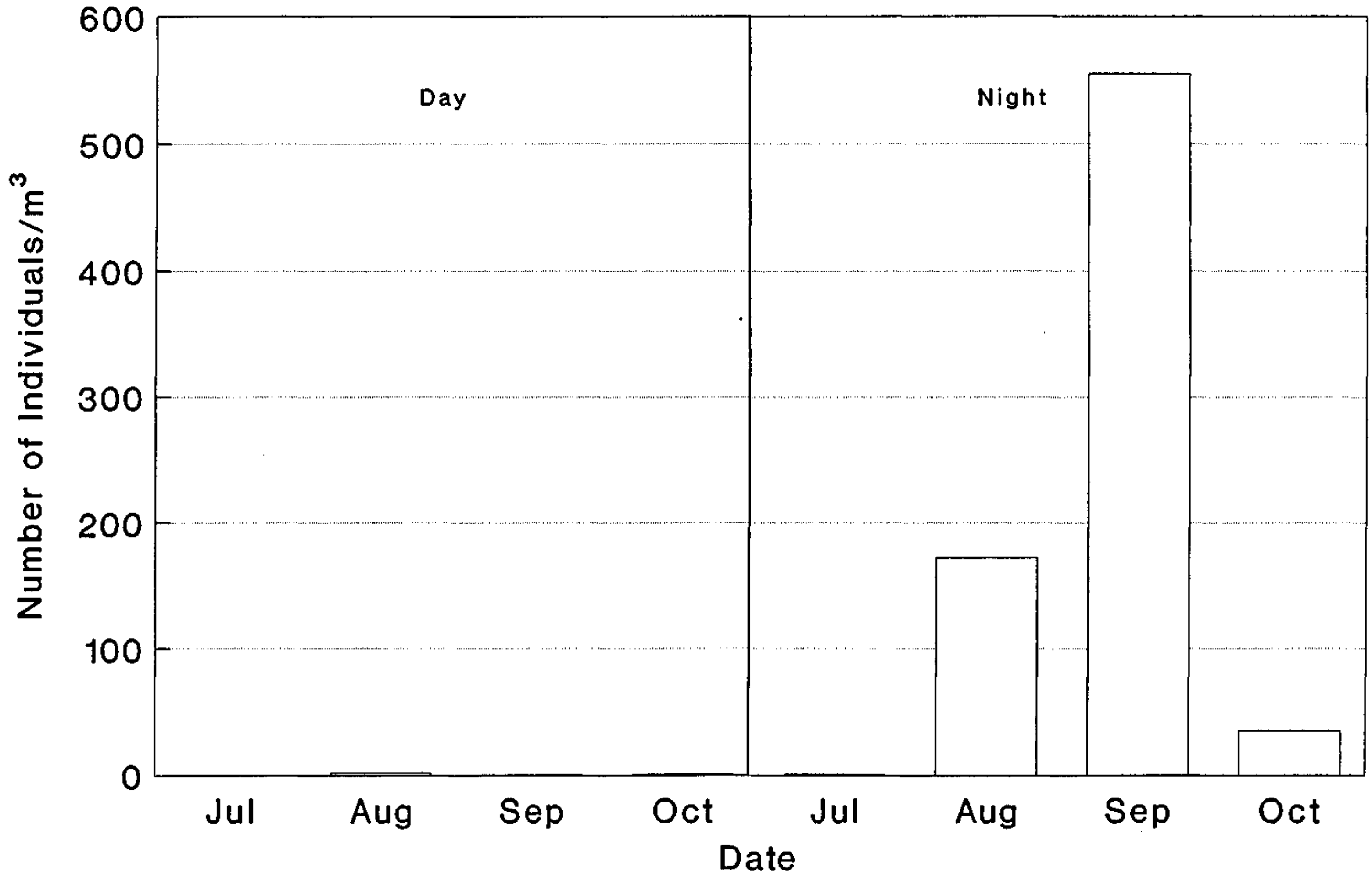


Figure 9. Concentrations of Copepods in 0.5m, 333μ Mesh Plankton Net Tows, Lower Mattole Lagoon 1987 Day and Night.

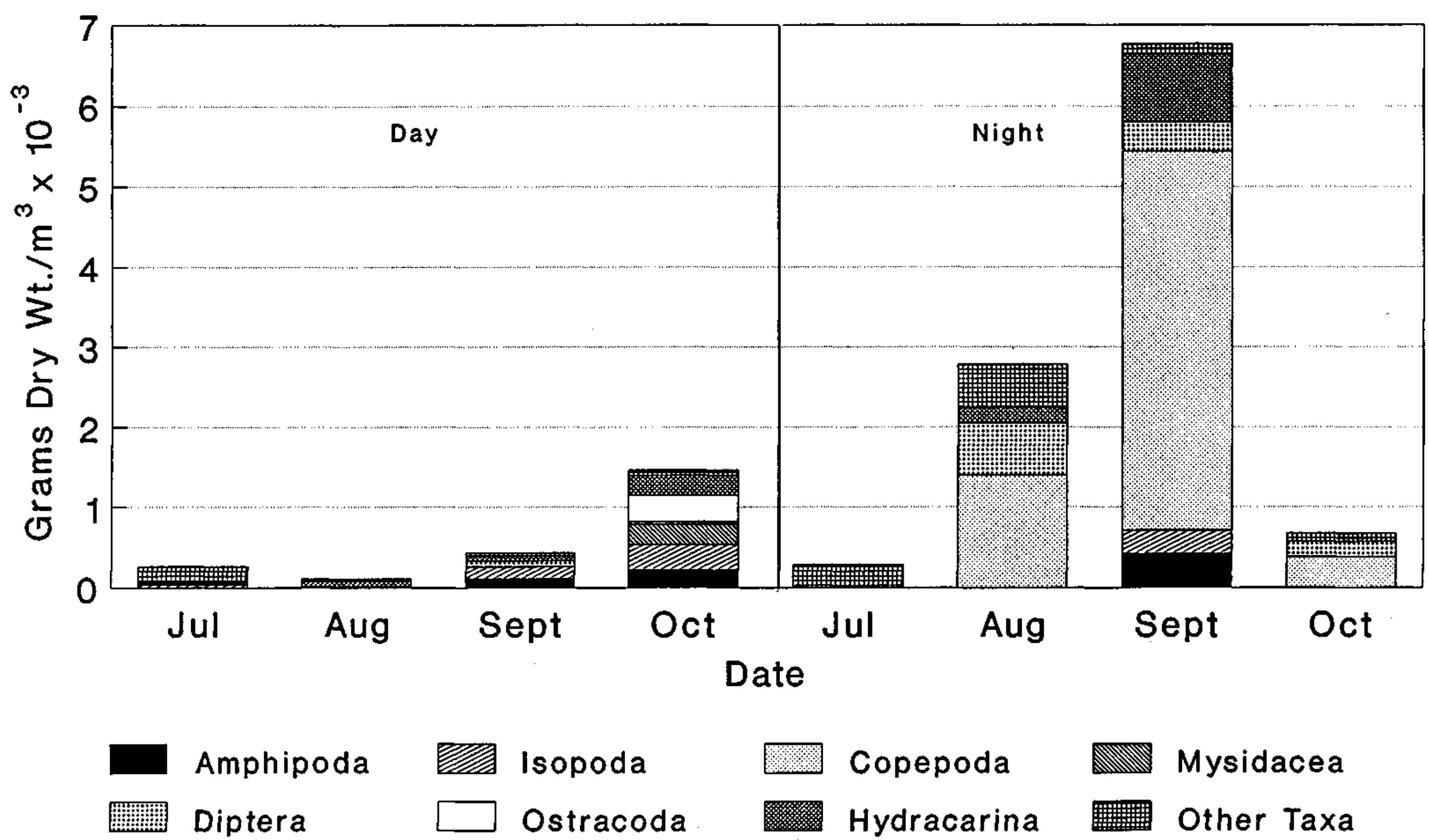


Figure 10. Biomasses of Planktonic Organisms in 0.5m, 333μ Mesh Plankton Net Tows, Lower Mattole Lagoon 1987 Day and Night.

Diptera larvae were among other taxa collected. Concentrations of Copepoda were significantly higher than those of all other taxa over the combined study period (all sampling dates) ($p < 0.05$). No significant differences were found between the other taxa.

Fish larvae contributed nearly half of the July biomass (Figure 10) (Appendix R). Diptera larvae, Hydracarina, and Amphipoda followed. A large increase in total biomass was observed in August. Copepoda had the greatest biomass followed by Diptera and fish larvae, Hydracarina, Coleoptera and Isopoda. Overall biomass increased greatly in September as Copepoda continued to bloom. Hydracarina, Amphipoda, Isopoda and Diptera larvae also contributed measurable amounts. In October, total biomass declined dramatically. Copepoda continued to account for the greatest percentage. Diptera larvae and other taxa combined contributed smaller proportions. Biomass of Copepoda was significantly greater than all other taxa with the exceptions of Diptera larvae and Hydracarina for the overall combined study period ($p < 0.05$). No significant differences in biomass were found between the other taxa.

Upper Site 1987

Daytime plankton samples, collected at the upper site in July and August, contained very few organisms (Figure 11) (Appendix S). Most of those collected were Diptera larvae and Hydracarina. A very large rise in zooplankton volume occurred in September. Similarly large numbers of Diptera larvae and Isopoda accounted for the majority. Amphipoda, Hydracarina and Ostracoda and Trichoptera larvae were among several other taxa collected. A sharp decline in zooplankton was observed in October. Ostracoda were the most abundant followed by Trichoptera larvae. Diptera larvae, Hydracarina and other taxa also collected. No significant differences in concentration were found between the taxa for the overall combined study period (all sampling dates).

Biomass of the July sample was below the measurable quantity (Figure 12) (Appendix T). Several taxa including Trichoptera and Diptera larvae contributed to the minute biomass estimated for August. An extremely large increase in overall biomass was observed in September. Isopoda and Amphipoda were the primary components contributing similar large, amounts. Diptera larvae and Hydracarina were among other taxa to have measurable quantities of biomass. A sharp decline was noted in October. Trichoptera larvae, Isopoda, Ostracoda, Diptera larvae, and Hydracarina

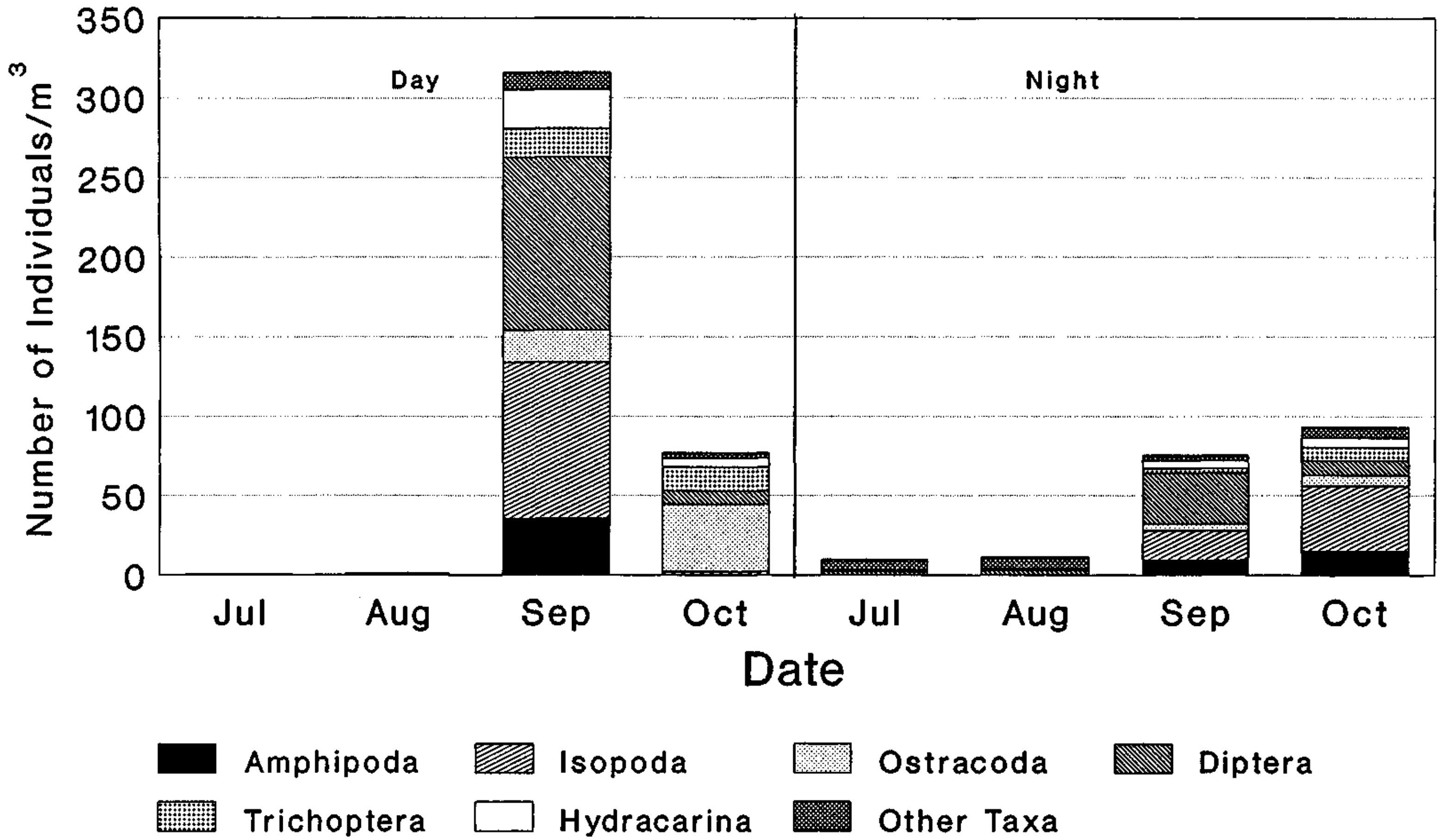


Figure 11. Concentrations of Planktonic Organisms in 0.5m, 333μ Mesh Plankton Net Tows, Upper Mattole Lagoon 1987 Day and Night.

were the leading contributors. No significant differences in biomass were found between the taxa for the overall combined study period (all sampling dates).

Several taxa were collected during night sampling in July (Figure 11) (Appendix U). Of these, Copepoda, and the larvae of Diptera, Trichoptera and Ephemeroptera were the most numerous. Similar zooplankton concentrations occurred in August. Representative taxa were also very similar. Oligochaeta, Diptera larvae and Hydracarina were present in the greatest quantities.

A large increase in zooplankton concentration was observed in September. Diptera larvae were the most numerous followed by Isopoda. Amphipoda, Ostracoda, Hydracarina and Trichoptera larvae were also present. Zooplankton abundance increased again in October. Isopoda were the most numerous by a substantial margin. Amphipoda, Diptera and Trichoptera larvae, Ostracoda and Hydracarina were among other taxa collected in significant numbers.

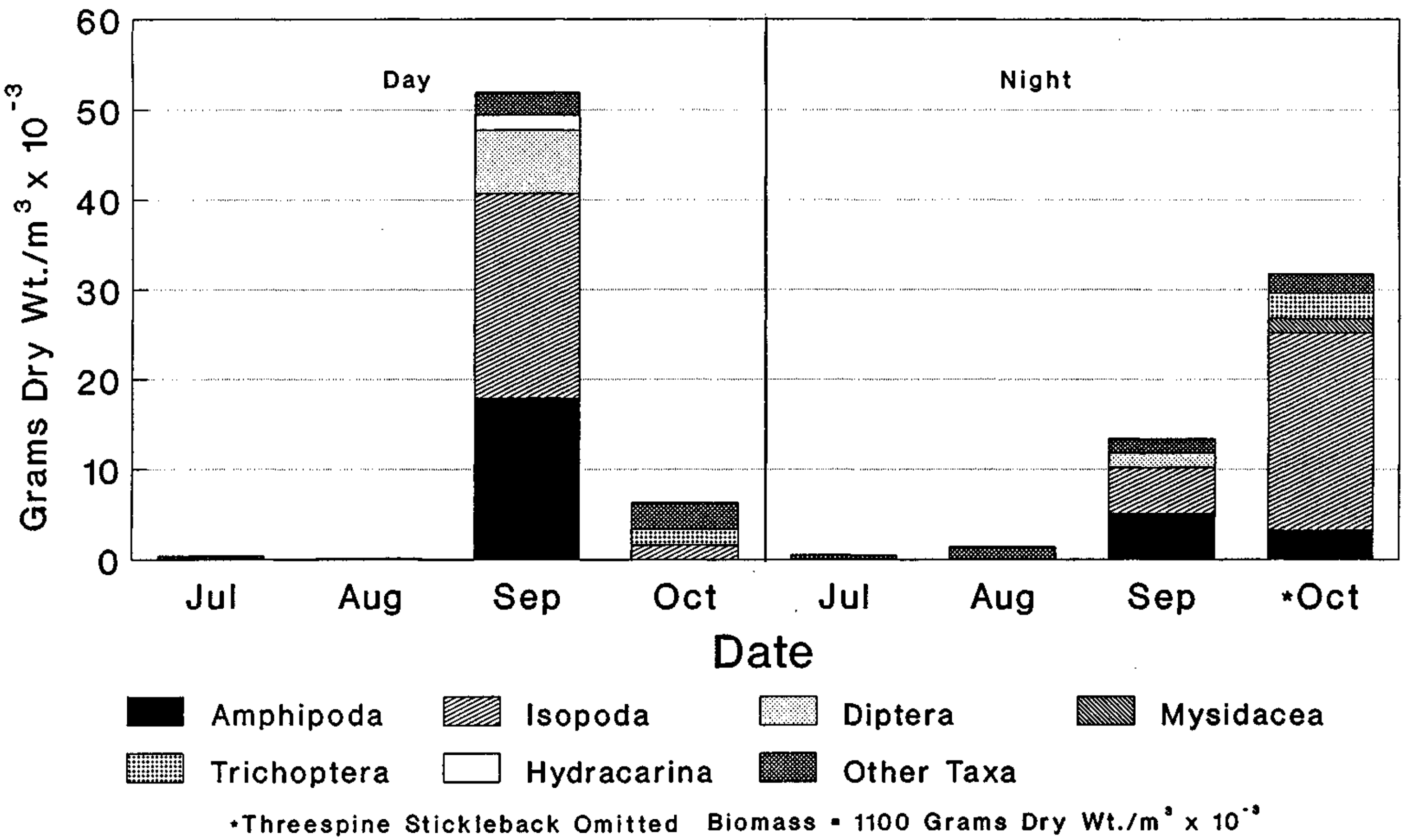


Figure 12. Biomasses of Planktonic Organisms in 0.5m, 333µ Mesh Plankton Net Tows, Upper Mattole Lagoon 1987 Day and Night.

Concentrations of Isopoda were significantly greater than those of Mysidacea, Coleoptera, Ephemeroptera and Odonata larvae, Hemiptera, Oligochaeta, Osteichthyes, and terrestrial insects for the combined study period (all sampling dates) ($p = 0.05$). No significant differences were found among the remaining taxa.

Numerous taxa contributed to the small estimated biomasses of night samples taken from the upper site in July and August (Figure 12) (Appendix V). Fish, Diptera, and Trichoptera larvae contributed the largest quantities followed by Mysidacea, Oligochaeta and Ephemeroptera larvae. Overall biomass increased substantially in September. Amphipoda and Isopoda were the leading components followed by Diptera larvae and the remaining taxa.

Juvenile threespine stickleback collected during night sampling at the lower site in October had the highest estimated mean biomass of the entire study by a wide margin. Thirty-five individuals, ranging in size from 11-35 millimeters were collected (Appendix W). The estimated biomass of stickleback was 1.1 grams dry weight/ cubic meter. This quantity was too large to include in Figure 12. Isopoda was the next largest contributor of biomass followed by Trichoptera larvae, Mysidacea and the remaining taxa. Although the biomass of threespine stickleback was quite large, no significant differences were found between the taxa the overall combined study period (all sampling dates).

Overall Results from 1987

No significant differences in overall zooplankton (all taxa) concentrations (#/m^3) were found between collection dates, sites or diel periods. The number of taxa collected was significantly larger in the upper lagoon ($p < 0.03$). No differences in number of taxa collected were found between dates and diel periods. No interaction was found to occur in concentrations, biomasses, or numbers of taxa collected between any of the dates, locations or diel periods.

Differences in overall biomass (all taxa) between sampling dates were marginally significant with October being the larger of the four ($p = 0.05$). No significant differences were detected between the other three dates or factors (location, diel period).

Juvenile Chinook Salmon Feeding Habits

A complete phylogenetic list of taxa identified in the stomachs of juvenile chinook salmon is given in Appendix X. Results of diet preference analyses (Johnson 1980) are shown in appendixes HH and II.

1986

Juvenile chinook salmon collected in late June had consumed mostly diptera adults and larvae (Figure 13) (Appendix Y). Terrestrials (mostly arachnida), adult hemiptera, and coleoptera were among other prey types consumed in significantly lesser numbers ($p < 0.05$). Further analysis, based on prey abundances, determined that diptera, terrestrials, and coleoptera were preferred significantly over the remaining taxa ($p < 0.05$)(Appendix HH). Volumes of the food types consumed were not significantly different (Figure 14) (Appendix Y).

In early July, chinook had consumed large numbers of diptera adults, larvae and terrestrials (Appendix Z). Numbers of terrestrials consumed were greater than all remaining taxa with the exceptions of adult coleoptera and hemiptera ($p = 0.05$). Terrestrials were preferred significantly over all other prey types. Hemiptera, diptera, and ephemeroptera were preferred second ($p < 0.05$). Differences between volumes of the food types

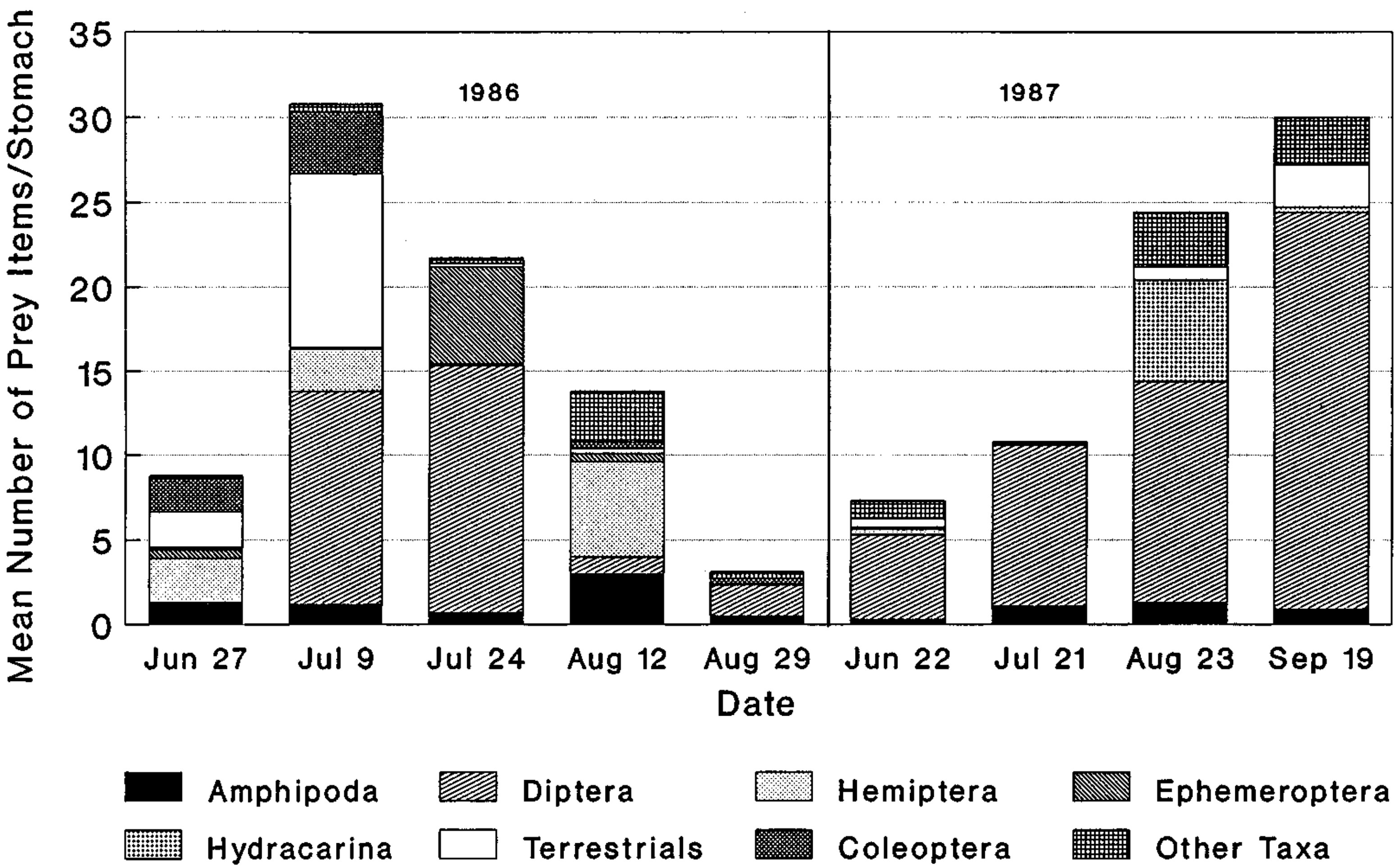


Figure 13. Mean Numbers of Prey Organisms Identified in Stomach Analysis of Juvenile Chinook Salmon, Mattole Estuary/Lagoon 1986 and 1987.

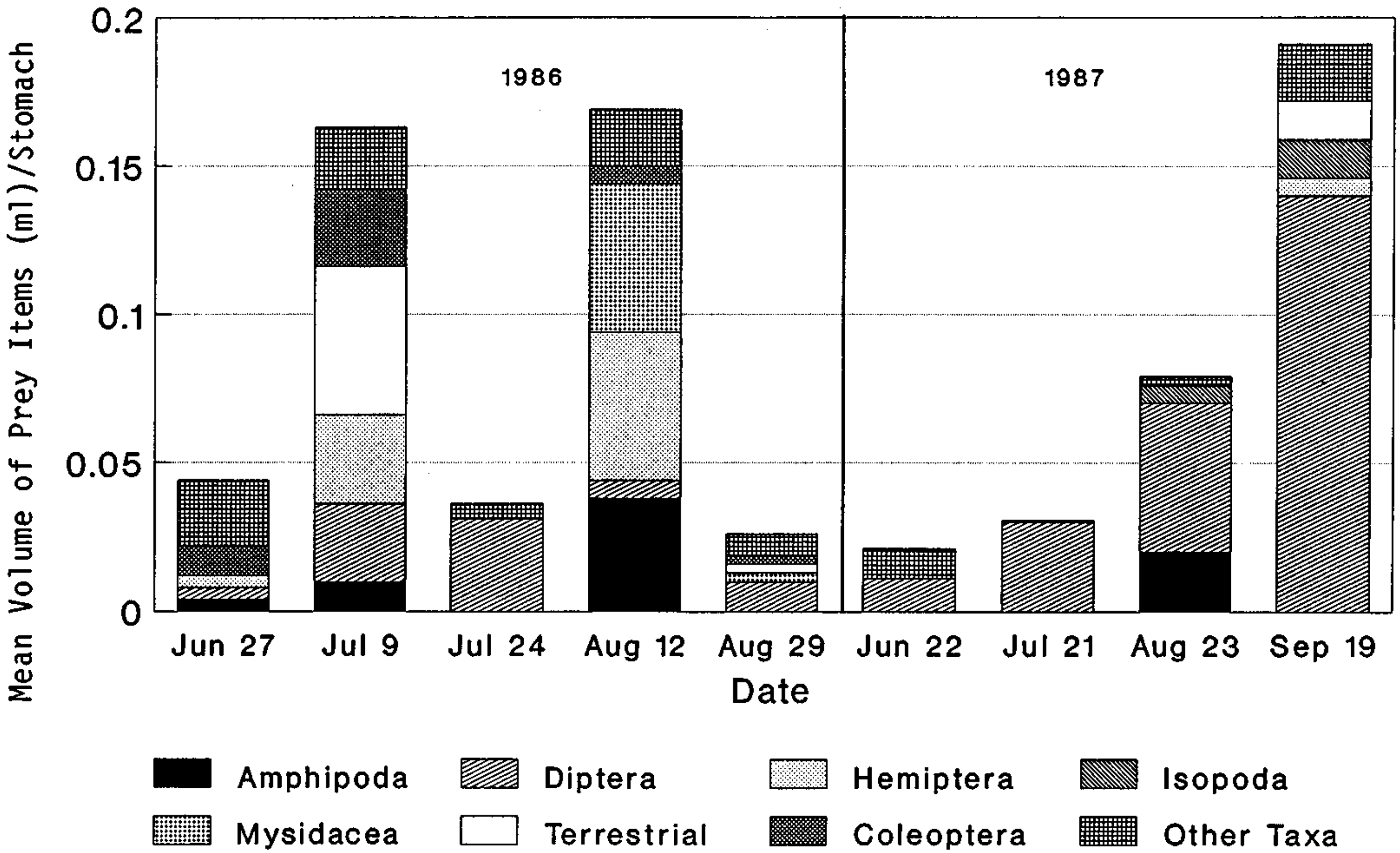


Figure 14. Mean Volumes of Prey Organisms Identified in Stomach Analysis of Juvenile Chinook Salmon, Mattole Estuary/Lagoon 1986 and 1987.

consumed were not significant.

Juvenile chinook collected in late July had consumed diptera larvae and adults almost exclusively (Appendix AA). No differences in numbers consumed were found among the remaining taxa . All prey categories were preferred significantly over amphipods. No other preferences were found among the food types ($p < 0.05$). Of all prey items, only diptera larvae and adults were present in significant volumes.

No significant differences were found between mean numbers of consumed prey items in early August (Appendix BB). Hemiptera, mysidacea, and amphipoda comprised the majority of the chinook diet. Coleoptera, ephemeroptera, diptera and hemiptera were preferred over amphipoda, mysidacea and the remaining taxa ($p < 0.05$). Coleoptera and ephemeroptera, however, occurred infrequently in the diet. Volumes of prey categories were not significantly different. Amphipoda, hemiptera and mysidacea accounted for most of the overall mean volume.

Mean numbers and volumes of prey organisms dropped sharply in late August (Appendix CC). Diptera adults and larvae were consumed in numbers significantly greater than the remaining taxa ($p < 0.05$). Coleoptera and ephemeroptera were again consumed infrequently but found to be preferred over the remaining taxa ($p < 0.05$). Mean volumes of the prey types consumed were not significantly different.

For the overall 1986 study period, Diptera larvae and adults were consumed in significantly greater numbers than the remaining taxa. Juvenile chinook collected in early July had consumed significantly greater numbers of prey organisms than those in late August but not the other three sampling dates ($p < 0.01$). Terrestrials and hemiptera were the overall preferred prey items ($p < 0.05$). Coleoptera, diptera and ephemeroptera followed next. The number of prey species consumed in early July was greater than in late July and August but not for the other two sampling dates ($p < 0.01$).

Mean volumes were not significantly different between the prey categories. Overall volumes consumed in early July and August, were significantly larger than those of late August but not the other two sampling dates.

1987

Juvenile chinook collected in June had consumed mostly diptera larvae and adults (Figure 13) (Appendix DD). No significant differences were found between mean numbers of other taxa consumed. Ephemeroptera and hemiptera were preferred over all other prey items in numbers followed by terrestrials ($p < 0.05$) (Appendix II). No differences between mean volumes of the prey types consumed were found (Figure 14). Diptera, however, were determined to be preferred by volume based on the amount available in plankton samples ($p < 0.05$).

Stomachs of chinook collected in July contained diptera larvae and adults almost exclusively (Appendix EE). No differences in mean numbers consumed were found between the remaining prey types. Amphipoda, however, were the preferred diet component by number based on prey availability ($p < 0.05$). Diptera was the only category present with measurable volume thus making them most abundant and preferred by volume.

In August, overall mean number of prey organisms per stomach increased sharply. Diptera larvae and adults, ephemeroptera larvae (mostly *Baetis* sp. and *Stenonema* sp.) and hydracarina were present in significantly higher mean numbers than the remaining prey categories ($p < 0.05$) (Appendix FF). Isopoda and ephemeroptera were the preferred diet components by number ($p < 0.05$). No significant differences were found between mean volumes of the identified food types. No individual prey category was preferred over any other by volume.

Diptera larvae and adults were present in the greatest numbers in September (Appendix GG) ($p < 0.05$). No significant differences were found between other prey types. Terrestrials were preferred in numbers over the other categories by a great margin ($p < 0.01$). Although the volume of diptera consumed was significantly larger than other taxa ($p < 0.05$), terrestrials were again found to be the preferred diet component ($p < 0.05$).

Diptera larvae and adults clearly were consumed in the greatest numbers over the entire 1987 study period ($p < 0.025$). No significant differences were found between any of the other prey categories. Juvenile chinook collected in August and September consumed significantly greater mean numbers of prey organisms than those of June and July ($p < 0.05$). No differences in number of prey categories consumed were found between sampling dates. Terrestrials and ephemeroptera were determined to be the overall preferred diet components by number ($p < 0.05$). Differences between overall mean volumes of individual prey categories were not significant. Overall mean volumes of prey items (all taxa) found in chinook stomachs collected in August and September were significantly greater than those of June and July ($p < 0.005$). Diptera were the preferred diet component by volume ($p < 0.05$). Other items found in the stomachs of juvenile chinook over both study periods included small pieces of gravel, bird feathers, green algae and other plant material including leaves, and wood.

DISCUSSION

Estuaries and coastal lagoons, especially smaller ones (such as the Mattole), are rapidly changing, highly dynamic systems and their biology cannot be understood except within the framework of their formation, evolution and subsequent decline (Barnes 1980). The biological community of the Mattole River estuary/lagoon appears to be greatly influenced by physical and chemical events throughout the period of juvenile chinook salmon residency (late spring - early fall). These events include timing of berm closure, seawater overwash during high tidal cycles and/or heavy surf, temperature, salinity, dissolved oxygen, wind, and the eventual breaching of the bar.

The biota of this ecosystem responds to the dynamic physical environment through changes in production, reproduction, competition, predation, mortality, and species composition. Historical evidence suggests that human activities in the estuary/lagoon, and elsewhere in the Mattole River drainage, have helped shape the current structure of the physical environment and its ecological community. Separate discussions of the epibenthos, plankton and juvenile chinook food habits studies follow.

Epibenthic Macrofauna

Numbers of epibenthic organisms collected at the lower site in 1986 increased gradually from late June through July (Figure 4). A decline was observed in August which continued through October. Numbers of *Corophium* also followed this pattern. No significant correlations were found between changes in numbers collected and the physical environment (temperature, salinity, dissolved oxygen concentration) (Appendix JJ). Vigorous wind mixing and accompanying bottom scouring may have contributed to the decline observed in August. After breaching of the berm in September, temperatures below 14.0 C and greatly increased stream flows probably combined to cause the further decline of *Corophium* seen in October.

At the upper site, numbers of epibenthic organisms increased on each sampling date from June through September (Figure 4). A sharp decline was experienced in October. *Corophium* again followed the trend of the overall community. No correlations between physical or chemical factors and organism abundance patterns were found (Appendix JJ). High tides and vigorous winds caused large volumes of seawater to wash over the sand bar into the lagoon in the late summer and early fall before breaching of the berm. High winds from the northwest pushed plumes of seawater into the upper lagoon (Busby et al. 1988).

Wind mixing and scouring were not observed at the upper site which was sheltered from the prevalent northwest winds by Moore Hill (Figure 3). Lack of wind mixing at the upper site sometimes allowed a dense lens of seawater on the bottom to absorb heat at a greater rate than the lighter freshwater above it due to density and optical properties. This phenomenon is known as meromixis (Lichatowich and Nicholas 1985).

Inverse thermal stratification was observed on two occasions at the upper site in 1986 including October 22. These conditions can persist over 24 hours and are often accompanied by low dissolved oxygen concentrations (Busby et al. 1988). Persistent meromixis followed by greatly increased stream flow were likely the leading factors accounting for the decline in numbers of epibenthic organisms observed in October.

Densities of epibenthic organisms at the lower site increased moderately from July through August 1987 (Figure 5). A decline was observed in September followed by a large increase in October. This pattern is quite different than the one observed in 1986. *Corophium* did not become the dominant component of the community until August. Biomasses of epibentic organisms followed the same trends as densities (Figure 6).

No correlations between changes in densities or biomasses of epibenthic organisms and physical or chemical factors were found (Appendix KK). Conditions for epibenthic organisms apparently were most favorable in October at the lower site.

A nearly identical pattern of change in benthic macrofaunal densities occurred at the upper site during 1987 (Figure 5). *Corophium*, however, were only the dominant component of the community until October when an extremely large increase of tubificid oligochaetes occurred (omitted from Figure 5 due to scale). Biomasses closely followed the pattern of density (Figure 6).

Densities of *Corophium* were weakly correlated with dissolved oxygen concentrations in the upper lagoon at maximum depth (R^2 = 0.91) (Appendix KK). Meromictic conditions were not observed in 1987 but dissolved oxygen concentrations below 3.0 ppm were measured at night and 5.0 ppm during the day (Busby et al. 1988). Low dissolved oxygen concentrations at night resulted from respiration by large amounts of benthic algae (Busby et al. 1988). This was perhaps the principal factor contributing to the observed decline of *Corophium* and the great increase of oligochaetes.

Studies reporting densities and biomasses of epibenthic invertebrates in estuaries of small coastal drainages in northern California, Oregon and Washington are few. Reimers et al. (1979) reported densities of

Corophium ranging from 2,125-33,671 individuals/m^2 (mean 12,351   10,789 SD) in the Sixes River estuary, Oregon (May 30 - Sept 10, 1979). The largest densities were estimated in late June. Gregory (1980) reported densities of *Corophium* ranging from 280 - 23,700 individuals/m^2 at three sites in the Mad River estuary, California during October 1980.

These two systems are similar to the Mattole estuary in that they are bar built and sometimes close. The occurrence and duration of mouth closure in these other estuaries, however, is considerably less and sometimes lasts only a single tidal cycle. Densities of *Corophium* in at the two sites in the Mattole estuary ranged from 244 - 5,600 individuals/m^2 during the 1987 study period. Peak abundances of *Corophium* occurred in October at the lower site and in August at the upper. Mean salinities are considerably higher and the salt wedge usually intruded further upstream in the Sixes and Mad River estuaries (Reimers 1973, Gregory 1980). Prolonged exclusion from marine influences (eg. increased temperatures, reduced salinity and marine inputs of organic carbon) probably accounted for the lower numbers of *Corophium* found in the Mattole River estuary during the summer months.

Inter-estuarine comparisons, however should be made with extreme caution. Large variations have been observed in populations of estuarine organisms between systems and from year to year (Simenstad and Wissmar 1984). Numerous physical factors including timing and volume of river discharge, and the degree and duration of coastal upwelling near marine-influenced systems, can contribute to the variability.

In the previous example, the studies of the Mattole, Mad and Sixes estuaries discussed were conducted in different years with different sampling equipment. It should be noted that estimated densities of *Corophium* collected during the September 1986 bucket type substrate sampler pilot study were 18,798   3685 SD which is similar to the higher numbers reported for the Mad River estuary in 1980 (Gregory 1980). It is also significantly greater than the estimated density of 4,376   2214 SD individuals of September 1987 ($p < 0.02$). Overall densities including all taxa were greater in September 1986 ($p < 0.01$). This suggests a high degree of inter-annual variability in the densities of epibenthic macrofauna in the Mattole River Estuary. In this comparison, identical sampling gear was used.

A few problems encountered during the epibenthic sampling are worth mentioning. Loss of 12 of the 20 samplers during the 1986 pilot study, greatly reduced the capability to estimate the sample size needed for 1987. The estimation method used gave a sample size adequate to estimate mean abundances but not to detect differences between sampling sites and dates. Had samplers from the lower site been retrieved and more than one month sampled, sample size required for two factor ANOVA (sampling site and date) could have been estimated based on the desired power of the test using the methods of Kirk (1968) as shown in Zar (1984 pages 227-228).

Further analysis, using the error MS from the 1987 epibenthic study, revealed that doubling sample size (16 total, 8 from each site on each date) will allow a 96% probability of detecting differences as low as 100 organisms per m^2 between sampling dates. The probability of detecting the same difference between sites with 8 samples, however, is only 62%. Thus more significant differences in densities between the taxa of epibenthic organisms may have been detected had more samples been collected.

Densities of epibenthic organisms in the upper estuary/lagoon are probably overestimated as surface area added from the irregular shapes of gravel and cobble were not taken into account. Only the length and width of the container was used to calculate surface area sampled. Three samples, one during the 1986 pilot study and two from July 1987 were discarded because of improper sealing of lids during retrieval. Containers of another design should probably be used in future studies unless adequate modifications can be made to alleviate this problem.

Planktonic Macrofauna

After closure of the sandbar occurs in the late spring or early summer, a slow transition from an estuarine to a freshwater plankton community takes place. This process appears to be complete by late July or early August in the lower lagoon and late August or early September in the upper lagoon. Rising plankton concentrations and biomasses signify the establishment of the new community. A similar process on a larger volume and longer time scale (years) is often observed after the filling of a new reservoir. A substantial amount of time is required for planktonic organisms to begin colonizing the new body of water.

Absence of *Corophium* in the plankton until the end of July or later suggests the beginning of a reproductive or recruitment period. Visual inspection revealed that *Corophium* collected in zooplankton samples were usually smaller than those found in the epibenthos. These juvenile *Corophium* undergo vertical migrations probably as a dispersal mechanism which minimizes intraspecific competition and ensures colonization of adjacent habitats (Nicholas et al. 1984). These vertical migrations begin after sunset.

Adult *Corophium*, which is primarily an epibenthic tube dwelling amphipod, also migrate into the upper water column at night during periods of reduced or absent moonlight (Nicholas et al. 1984). Adults, however, were observed far less frequently than juveniles in the Mattole River Lagoon plankton. Adult and juvenile *Corophium* are never found in the water column at the same time (Nicholas et al. 1984). Adult *Neomysis* and *Gnorimosphaeroma* also made vertical migrations at night. Aquatic insect larvae and adults present in plankton samples represented drift.

No other statistically significant correlations were found between changes in the abundances and biomasses of planktonic organisms and temperature, salinity or dissolved oxygen concentrations in 1986 (Appendix LL). Daytime concentrations of zooplankton in the lower lagoon were strongly correlated with salinity in 1987 (Appendix MM). Concentrations of zooplankton in the lower lagoon were greater when vigorous wind mixing was suspending bottom sediments in the late summer and early fall. This event has been documented as being important in the recycling of organic nutrients and detritus settled on the bottom and it enhances production of zooplankton (Tenore 1977, Barnes 1980, Simenstad 1983). Seawater washing over the bar during high tides also seemed to enhance the production of zooplankton in the lagoon. This is probably due to the nutrient rich character of this cooler, upwelled coastal water.

Estimates of zooplankton concentrations and biomasses in the upper lagoon may be high. Because of the shallow depths, organisms on the bottom may have been stirred up by the boat propeller and collected in the net. This would be most probable in the late summer months when minimum depths occurred (Busby et al. 1988).

All of the factors which may contribute to the inter-annual variability seen in populations of epibenthic organisms may also affect zooplankton. In fact, planktonic organisms are often more sensitive than benthic animals to changes in the physical and chemical characteristics of the environment.

Feeding Habits of Juvenile Chinook Salmon

Juvenile chinook collected during June, 1986 fed on planktonic or drifting prey items such as terrestrials, swimming hemiptera, diving coleoptera and diptera larvae and adults (Figure 13, Appendix X). Terrestrial insects and hemiptera were the preferred prey organisms for the overall 1986 study period (Appendix HH). Selection (usage) did not closely follow availability of prey in the plankton (Figures 7 and 13).

Juvenile chinook collected in 1987 exhibited somewhat different feeding behavior than what was observed in 1986. Ephemeroptera larvae and terrestrial insects were preferred by number for the overall 1987 study period (Appendix II). Diptera larvae and adults comprised most of the volume ($p < 0.05$) (Figure 14). Selection (usage) of prey organisms followed availability of plankton more closely in 1987 than in 1986 (Figures 7-14).

Differences between mean numbers and volumes of prey organisms consumed in late June, July and August of 1986 and 1987 were not statistically significant (Appendixes Y-GG). A significant interaction between month and year collected was detected for both numbers and volumes ($p < 0.05$). This means that both the month and year of collection together contributed to differences observed in the overall mean numbers and volumes of prey items consumed. Mean numbers of prey categories (species) consumed were not significantly different over these same dates. Mean fork lengths and weights of juvenile chinook collected in 1986 were significantly larger than 1987 ($p < 0.001$)(Busby et al. 1988).

Juvenile chinook depended heavily on allochthnous food (terrestrial and aquatic insects, diptera larvae and adults) from windborne and riverine drift sources in early 1986. This was a period of peak juvenile chinook abundance (Busby et. al. 1988) and low zooplankton concentration. Later in the study period (early August), diet shifted to autochthonous sources (Hemiptera, juvenile

Corophium and *Neomysis*). This indicates that feeding was mostly neustonic and sometimes just below the surface or at mid depths. There is no indication that any epibenthic feeding occurred during the 1986 study period.

Juvenile chinook collected in 1987 relied more heavily on drift than in 1986. This was shown by the lower occurrences of terrestrial insects (a preferred food type) in the 1987 diet. In addition, diptera larvae comprised a somewhat greater proportion of the diet throughout 1987 (Figures 13 and 14). No dramatic shifts in diet were observed with the exception of an increase in consumption of ephemeroptera larvae, isopoda and hydracarina in late August. There was no indication of epibenthic feeding by juvenile chinook salmon during the 1987 study period.

Despite their often high levels of abundance, *Corophium* were infrequently found in chinook stomachs. This may be due to cyclic availability. Field and laboratory observations suggest that only 0.1 to 2.5% of the epibenthic standing crop of *Corophium* are out of their tubes and visible to feeding fish at any given time (Reimers et al. 1979). These values are probably substantially less in the Mattole lagoon where a dense algal mat covers the bottom, effectively obscuring any epibenthic prey from view. Because of these conditions, epibenthic feeding is probably impossible or at best difficult in the lower lagoon where juvenile chinook were collected and observed (Busby et al. 1988). This suggests that feeding on *Corophium* only occurs during periods of vertical migration which were described earlier.

Preference analysis revealed that *Corophium* were often avoided as a food resource by juvenile chinook (Appendixes HH and II). Laboratory studies have shown that *Corophium* display an interesting defense behavior which may further reduce their desirability as prey (Reimers et al. 1979). When an adult *Corophium* was grabbed by a fish, it usually assumed a "splayed" posture, extending its first antennae up and out and its second antennae down and out, making it very difficult for young salmon to ingest. The spiny antennae of *Corophium* in this position often hook around salmon mouth parts or become wedged in the esophagus of the fish. *Corophium* were frequently observed being regurgitated by young salmon several minutes after ingestion and walking away unharmed.

Although *Corophium* were found to be the main component in the diet of juvenile chinook salmon during several studies in the Sixes River estuary, Oregon (Nicholas et al. 1984) this was not the case in the Mattole estuary\lagoon. Studies on the Redwood Creek estuary, Humboldt County, California, a system with physical characteristics to those of the Mattole, revealed that juvenile chinook relied mostly on drift organisms, especially in the spring and early summer (Larson 1987, Salamunovich 1987).

Terrestrial insects were also a very important component of the diet in the Redwood Creek estuary as was found in the Mattole. Salamunovich (1987) reported a shift from terrestrial insects to diptera as was observed in the Mattole in 1986. Pearce and Meyer (1982) reported a shift in chinook diet from spiders and diptera to larger crustacea such as *Corophium* and *Neomysis* at a fork length of about 70mm. This seems to have occurred in the Mattole estuary in 1986 but not 1987. Seawater washing over the berm during high tides in late summer 1986 may have influenced the observed shift in diet.

Juvenile chinook have been documented to use a wide variety of feeding strategies. Benthic feeding was demonstrated by Reimers et al. (1979) and Nicholas et al. (1984) in the Sixes River estuary, Oregon. Reliance on drift was shown by Salamunovich (1987) in the Redwood Creek estuary, California and the Mattole (this study). Kjelson et al. (1982) demonstrated the importance of planktonic crustacea in the diet of juvenile chinook in the Sacramento, San Joaquin delta. The importance of zooplankton was also demonstrated in the Columbia River estuary by Craddock et al. (1976) and McCabe et al. (1986).

Geographic differences in feeding strategies suggest that physical characteristics of the environment probably influence the feeding strategy used. Feeding of juvenile chinook has been demonstrated to vary over time and between habitats within the same system. This was substantiated by Healey (1980,1982) who found temporal and spatial differences in juvenile chinook diet in the Nanaimo River estuary, B.C., Canada. McCabe et al. (1986) found that subyearling chinook of varying sizes differentially utilized habitat types and food resources in the Columbia River Estuary.

Partitioning of habitat and food resources between several juvenile salmonid species including chinook was demonstrated by Macdonald et al. (1987) in the Campbell River estuary B.C., Canada. In the Redwood Creek estuary, juvenile steelhead consumed mostly epibenthic macrofauna while chinook relied primarily on drift (Salamunovich 1987). This was also the case in the Mattole estuary. Direct observations and sampling have revealed that few juvenile chinook utilize the upper estuary/lagoon which is heavily populated with steelhead (Busby et al. 1988, Zedonis and Barnhart 1989). Large quantities of potential epibenthic prey organisms were present in that habitat.

Surface area and depth probably play an important role in the determination of juvenile chinook feeding strategy. Planktonic crustacea appear to be most important in larger, deeper estuaries such as the Columbia

(Craddock et al. 1976, McCabe et al. 1986), the Sacramento-San Joaquin delta (Kjelson et al. 1982), and the Campbell River estuary B.C. Canada (Macdonald et al. 1987). In smaller, sometimes closed systems such as the Mattole River and Redwood Creek estuaries, the absence of marine inputs of organisms, detritus and other sources of organic carbon probably magnifies the importance of riverine sources.

Downstream migrating juvenile chinook salmon in the Mattole River arrive to a relatively food-barren estuary or lagoon in the late spring and early summer. The number of chinook that are forced to rear in the lagoon through the summer months appears to be a function of the timing of bar closure which depends on river discharge. In years of early closure (late May, early June) large numbers of chinook are trapped behind the bar and subsequently experience great mortality and periods of suppressed growth (Young 1987, Busby et al. 1988). This is because peak periods of zooplankton and drift abundance lag behind peak abundances of juvenile chinook. In years of later berm closure, fewer juvenile chinook were present suggesting that a greater proportion were allowed to enter the ocean (Barnhart and Young 1985, Barnhart and Busby 1986, Zedonis and Barnhart 1989). Lagoon resident chinook in 1984, 1986, and 1988 experienced less dramatic mortality rates and grew more rapidly and to larger sizes than in 1985 and 1987. A preliminary examination of scales from returning adults suggests that the majority of these Mattole chinook were not estuary or lagoon residents (Hinkson 1987).

The interannual variability in mortality and growth demonstrates the limited capacity of the Mattole estuary to produce juvenile chinook. True estuaries have been demonstrated to be habitats capable of enhancing the growth and oceanic survival of juvenile chinook (Reimers 1973, Healey 1980, Simenstad et al. 1982). Having an opening at all times, a true estuary allows chinook to outmigrate when environmental stresses begin to reduce growth or inflict mortality.

This interannual variability in mortality and growth of juvenile chinook also shows the limited carrying capacity of the Mattole estuary/lagoon. Actual "carrying capacity" of the habitat depends on physical characteristics such as timing of berm closure, wind, and oceanic upwelling among other factors previously mentioned. This "capacity" to support populations of anadramous salmonids varies from year to year and was obviously exceeded in 1985 and 1987 as high mortality and poor growth were experienced (Young 1987, Busby et al. 1988). This was further evidenced in 1987 as mean numbers and volumes of prey items in chinook stomachs increased as chinook population size decreased and growth increased

(Figures 13 and 14) (Busby et al. 1988). This suggests great competition for food resources at high population densities.

Interannual variability in estuarine and oceanic productivity may limit our ability to enhance salmonid populations (Simenstad and Wissmar 1984). For example, feeding overlap and competition between wild and introduced hatchery stocks may be of concern as growth and survival may be limited when salmonid population levels exceed the carrying capacity of the estuary (Reimers 1973, Reimers 1978a, Reimers and Concannon 1977, Nicholas et al. 1979, Meyers and Horton 1982, Simenstad et al. 1982). In this case, the release of large numbers of hatchery fish to enhance adult returns could produce negative impacts on both wild and hatchery salmon stocks and food organism communities during a year of below normal estuarine or oceanic productivity.

Recent observations and experimental evidence suggests that salmonid fishes in small coastal drainages and their estuaries can experience high mortality from predation and environmental stresses. Wood (1978a,b) found that common mergansers (*Mergus merganser*) consumed 24-65% of the wild coho salmon production from two coastal streams on Vancouver Island B.C., Canada. Macdonald et al. (1988) found that juvenile chinook in the Campbell River estuary B.C., Canada, were extremely vulnerable to predation by a variety of seabirds. It was also found that osmoregulatory stresses from premature encounters with saline water induced some mortality (Macdonald et al. 1988). Sudden changes in salinity from seawater washing over the bar may produce similar effects in the Mattole lagoon.

Sampling and direct observations in the Mattole and other estuaries reveals that cooler, deep water habitats with measurable salinity are the preferred habitats of juvenile chinook salmon (Reimers et al. 1978, Macdonald et al. 1987, Busby et al. 1988). This habitat is in short supply in the Mattole estuary/lagoon. Historical accounts reveal that the Mattole estuary was once much deeper and perhaps larger than at present (Roscoe 1977). Subsequent filling of the estuary with suspended and bedload sediments from geologic activities, often accelerated by human activities upstream, greatly reduced the ability of the intruding tidal prism to scour and remove this material. Seasonal closure of the mouth is the result of this excess sedimentation, waves, longshore transport and other factors which have been recently demonstrated in the Eel River delta (U.S. Soil Conservation Service 1989). A management plan to reduce sediment loading, restore tidal flushing and thus deepen the Eel delta is currently being undertaken by the U.S. Soil Conservation Service and the Eel River Resource Conservation District (U.S. Soil

Conservation Service 1989). If successful, this program should restore deep water juvenile chinook habitat in that system. Similar actions should be considered for the Mattole River estuary to expand the amount of quality juvenile chinook salmon rearing habitat. The importance of terrestrial insects in the diet of chinook collected in early 1986 suggests that enhancement projects designed to increase the amount of riparian vegetation surrounding the estuary would also be of substantial benefit to juvenile chinook.

Literature Cited

Allen, M.A. and T.J. Hassler. 1986. Species profiles: Life histories and environmental requirements of coastal fishes and invertebrates (Pacific southwest), chinook salmon. United States Department of the Interior, Fish and Wildlife Service. Biological Report 82(11.49). 26 pp.

Barnes, R.D. 1980. Invertebrate zoology. 4th ed. Saunders\Holt Rinehart and Winston, Philadelphia, PA., USA. 1089 pp.

Barnes, R.S.K. 1980. Coastal lagoons. Cambridge University Press, Cambridge, UK. 94pp.

Barnes, R.S.K. 1984. Estuarine biology. 2nd ed. Edward Arnold Publishing, Baltimore, MD., USA. 76pp.

Barnhart, R.A. and M.S. Busby. 1986. An investigation of the Mattole River lagoon, June 1986 to October 1986. Bureau of Land Management, Arcata, CA. 38pp.

Barnhart, R.A. and D.A. Young. 1985. An investigation of the Mattole River estuary, May 1984 to March 1985. Bureau of Land Management, Arcata, CA. 26pp.

Beauchamp, D.A., M.F. Shepard, and G.P. Pauley. 1983. Species profiles: Life histories and environmental requirements of coastal fishes and invertebrates (Pacific northwest), chinook salmon. United States Department of the Interior, Fish and Wildlife Service. FWS/OBS - 82/11.6. 15pp.

Borror, D.J., D.M. DeLong, and C.A. Triplehorn. 1981. An introduction to the study of insects. 5th ed. Sanders College Publishing, New York, NY., USA. 827pp.

Bottom, D., R. Kreag, F. Ratti, C. Raye and R. Starr. 1979. Habitat classification and inventory methods for the management of Oregon estuaries. Oregon Department of Fish and Wildlife, Research and Development Section. Estuary Inventory Report, Volume 1.

Busby, M.S., R.A. Barnhart and P.P. Petros. 1988. Natural resources of the Mattole River estuary, California. Natural Resources and Habitat Inventory Summary Report. Bureau of Land Management, Arcata, CA. 81pp.

California Department of Fish and Game. 1965. California fish and wildlife plan. Volume III, supporting data part B; inventory salmon-steelhead and marine resources. California Resource Agency, Department of Fish and Game. Sacramento. 356pp.

California Department of Water Resources. 1973. Character and use of rivers, Mattole River. State of California Resources Agency, Department of Water Resources. 145pp.

California Department of Water Resources. 1974. Water management for fishery enhancement on north coastal streams. State of California Resources Agency, Department of Water Resources. 68pp.

Cannon, T.C. 1982. The importance of the Sacramento - San Joaquin estuary as a nursery area of young chinook salmon, striped bass and other fishes. Report to the National Marine Fisheries Service, Southwest region. 102pp.

Cowardin, L.M., V. Carter and E.T. LaRoe. 1979. Classification of wetlands and deepwater habitats of the United States. United States Department of the Interior, Fish and Wildlife Service, Biological Services Program Report FWS/OBS - 79/31. 103pp.

Craddock, D.R., T.H. Blahm and W.D. Parente. 1976. Occurrence and utilization of zooplankton by juvenile chinook salmon in the lower Columbia River. Transactions of the American Fisheries Society 1:72-76.

Gilbert, C.H. 1913. Age at maturity of the Pacific coast salmon of the genus *Oncorhynchus*. Bulletin of the United States Bureau of Fisheries. 32:1-22.

Gregory, R., ed. 1980. Unpublished. Mad River estuary. Class projects from ecology of estuarine organisms, fall 1980, Dr. George Crandell, Humboldt State University, Arcata, CA.

Grosse, D.J. and G.B. Pauley. 1986. Species profiles:

Life histories and environmental requirements of coastal fishes and invertebrates (Pacific northwest), Amphipods. United States Department of the Interior, Fish and Wildlife Service. Biological Report 82(11.69).

Harris, M., G. Horvitz, and A.M. Mood. 1948. On the determination of sample sizes in designing experiments. Journal of the American Statistical Association 43:391-402.

Healey, M.C. 1979. Detritus and juvenile salmon production in the Nanaimo estuary: I. Production and feeding rates of juvenile chum salmon, *Oncorhynchus keta*. Journal of the Fisheries Board of Canada 36: 488-496.

Healey, M.C. 1980. Utilization of the Nanaimo estuary by juvenile chinook salmon, *Oncorhynchus tshawytscha*. Fishery Bulletin 77:653-668.

Healey, M.C. 1982. Juvenile Pacific salmon in estuaries: The life support system. Pages 315-341 <u>in</u>: V. Kennedy (ed.), Estuarine Comparisons. Academic Press, New York, NY. USA. 709 pp.

Hinkson, E. 1987. Unpublished. Using scale analysis to determine the time spent by juvenile chinook salmon in the Mattole River estuary. California Cooperative Fisheries Research Unit, Humboldt State University, Arcata, CA. 8pp.

Hofstra, T.D. 1983. Management alternatives for the Redwood Creek estuary. Redwood National Park, Arcata, California. 50pp.

Johnson, D.H. 1980. The comparison of usage and availability measurements for evaluating resource preference. Ecology 61:65-71.

Joseph, J. 1958. First annual report of the Big Lagoon project volumes 1 and 2. Humboldt State University. Arcata, CA., USA. 163pp.

Kjelson, M.A., P.F. Raquel and F.W. Fisher. 1982. Life history of fall-run juvenile chinook salmon, *Oncorhynchus tshawytscha*, in the Sacramento - San Joaquin estuary, California. Pages 393-411 <u>in</u> V. Kennedy (ed.), Estuarine comparisons. Academic Press, New York, NY. USA. 709 pp.

Larson, J.P. 1987. Utilization of the Redwood Creek estuary, Humboldt County, California by Juvenile Salmonids. M.S. Thesis, Humboldt State University, Arcata, California. 79pp.

Lichatowich, T.J., and J.W. Nicholas. 1985. Seasonal meromixis in the Winchuck estuary: Implications to production of wild chinook salmon in certain Oregon estuarine. Oregon Department of Fish and Wildlife, Research and Development Section, Fish Division. Information Report Series 85-11. 8pp.

Lotus Development Corporation. 1987. Lotus 1-2-3 software and user manual. Lotus Development Corporation, Cambridge, Massachusetts. 450pp.

McCabe, G.T.Jr., R.L. Emmet, W.D. Muir and T.H. Blahm. 1986. Utilization of the Columbia River estuary by subyearling chinook salmon. Northwest Science 60:113-124.

McKeon, J.F. 1985. Downstream migration, growth, and condition of juvenile fall chinook salmon in Redwood Creek, Humboldt County, California. M.S. Thesis, Humboldt State University, Arcata, California. 90pp.

Macdonald, J.S., I.K. Birtwell, and G.M. Kruzynski. 1987. Food and habitat utilization by juvenile salmonids in the Campbell River estuary. Canadian Journal of Fisheries and Aquatic Sciences 44:1233-1246.

Macdonald, J.S., C.D. Levings, C.D. McAllister, U.H.M. Fagerlund and J.R. McBride. 1988. A field experiment to test the importance of estuaries for chinook salmon survival: Short term results. Canadian Journal of Fisheries and Aquatic Sciences 45:1366-1377.

Merritt, R.W., and K.W. Cummins, eds. 1985. An introduction to the aquatic insects of North America. Second edition. Kendall-Hunt Publishing Company. Dubuque, Iowa. 722pp.

Meyers, K.W. and H.F. Horton. 1982. Temporal use of an Oregon estuary by hatchery and wild juvenile salmon. Pages 315-341 in V. Kennedy (ed.), Estuarine Comparisons. Academic Press, New York, NY. USA. 709 pp.

Naiman, R.J. and J.R. Sibert. 1979. Detritus and juvenile salmon production in the Nanaimo estuary: III. Importance of detrital carbon to the estuarine ecosystem. Journal of the fisheries research board of Canada 36:504-520.

Nicholas, J.W., P.E. Reimers and J.M. Hutchinson. 1979. The potential impact of releasing hatchery coho salmon on wild juvenile chinook salmon in the Siuslaw estuary. Oregon Department of Fish and Wildlife, Research and development Section, Corvallis. Information Report Series, Fisheries Number 79. 7pp.

Nicholas, J.W., T.W. Downey, D. Bottom, and A. McGie. 1984. Fish Research Project, Annual progress report. Oregon Department of Fish and Wildlife, Portland. 82-ABD-ORIE. Pages 15-21.

Nicholas, J.W., and D.G. Hankin. 1988. Chinook salmon populations in Oregon coastal river basins: Description of life histories and assessment of recent trends in run strengths. Oregon Department of Fish and Wildlife, Research and Development Section. Information Reports 88-1. 359pp.

Odum, W.E., J.S. Fisher and J.C. Pickral. 1979. Factors controlling the flux of particulate organic carbon from estuarine wetlands. Pages 69-80 in: R.J. Livingston (ed.), Ecological Processes in Coastal and Marine Systems. Plenum Press, New York, NY., USA.

Pearce, T.A. and J.H. Meyer. 1982. Distribution and food habits of juvenile salmon in the Nisqually estuary, Washington, 1979-1980. United States Department of the Interior, Fish and Wildlife Service, Fisheries Assistance Office Olympia, WA., USA. 77pp.

Peterson, G.D. 1985. Annual Report, 1984-1985 season. Mattole Watershed Salmon Support Group, Petrolia, California. 7pp.

Pritchard, D.W. 1967. What is an estuary ?: Physical viewpoint. Pages 3-5 in G.F. Lauff (ed.), Estuaries. American Association for the Advancement of Science. Publication 83. Washington, D.C., USA.

Reimers, P.E. 1973. The length of residence of juvenile fall chinook salmon in the Sixes River, Oregon. Research Reports of the Fish Commission of Oregon 4(2). 43pp.

Reimers, P.E. 1978. The need for research on the estuarine ecology of juvenile chinook salmon. Oregon Department of Fish and Wildlife, Research Section. Information Report Series, Fisheries 78(4). 10pp.

Reimers, P.E., J.W. Nicholas, T.W. Downey, R.E. Haliburn, and J.D. Rogers. 1978. Fall chinook ecology project. Oregon Department of Fish and Wildlife, Research and Development Section Annual Progress Report, Project Number AFC-76-2, October 1, 1977 to September 30, 1978. 52pp.

Reimers, P.E., J.W. Nicholas, D.L. Bottom, T.W. Downey, K.M. Maciolek, J.D. Rodgers, B.A. Miller. 1979. Coastal Salmon Ecology Project, Oregon Department of Fish and Wildlife, Fish Research Project Annual Progress Report. Project Number AFC-76-3, October 1, 1978 to September 30, 1979. 45pp.

Reimers, P.E. and G.L. Concannon. 1977. Extended residence of hatchery-released juvenile chinook salmon in Elk River, Oregon. Oregon Department of Fish and Wildlife, Research Section, Information Report Series, Fisheries 77(2). Portland. 17pp.

Reimers, P.E. and T.W. Downey. 1982. Population dynamics of fall chinook salmon in Sixes River. Oregon Fish and Wildlife, Annual Progress Report, Project Number AFC - 102, Fish Research and Development Project, Fisheries Division, Portland. 17pp.

Roscoe, J. 1977. The Mattole valley, survival in a rural community. Unpublished Class Report. Humboldt County Collection. Humboldt State University, Arcata, CA. 60 pp.

Ryan, B.F., B.L. Joiner and T.A. Ryan Jr.. 1985. Minitab. Software and handbook. 2nd ed. PWS-Kent Publishing Company, Boston, MA. 379 pp.

Salamunovich, T.J. 1987. Fish food habits and their interrelationships in lower Redwood Creek, Humboldt County, California. M.S. Thesis, Humboldt State University, Arcata, California. 173 pp.

Sibert, J. 1979. Detritus and juvenile salmon production in the Nanaimo estuary: II. Meiofauna available as food to juvenile chum salmon, *Oncorhynchus keta*. Journal of the Fisheries Research Board of Canada 36:497-503.

Sibert, J., T.J. Brown, M.C. Healey, B.A. Kask, and R.J. Naiman. 1977. Detritus-based food webs: Exploitation by juvenile chum salmon (*Oncorhynchus keta)*. Science 196:649-650.

Sibert, J.R. and B.A. Kask. 1978. Do fish have diets? Pages 48-57 in: B.G. Shepard and M.J. Genetz (eds.), Proceedings of the 1977 Northeast Pacific Chinook and Coho Salmon Workshop. Marine Fisheries Service of Canada, Technical Report 759.

Smith, J.J. 1987. Aquatic habitat and fish utilization of Pescadero, San Gregorio, Wadell and Pomponio Creek estuary\lagoon systems. San Jose State University and the California Department of Parks and Recreation. Agreement 4-823-6004. 35pp.

Smith, R.I., and J.T. Carlton (eds.). 1975. Lights Manual, intertidal invertebrates of the central California coast. 3rd ed. University of California Press, Berkely. 716pp.

Simenstad, C.A. 1983. The ecology of estuarine channels of the Pacific Northwest coast: a community profile. United States Department of the Interior, Fish and Wildlife Service. FWS/OBS - 83/05. 181 pp.

Simenstad, C.A., K.L. Fresh and E.O. Salo. 1982. The role of Puget Sound and Washington coastal estuaries in the life history of Pacific salmon: An unappreciated function. Pages 343 - 364 in: V. Kennedy (ed.), Estuarine Comparisons. Academic Press, New York, NY. USA. 709 pp.

Simenstad, C.A., and R.C. Wissmar. 1984. Variability of estuarine food webs and production may limit our ability to enhance Pacific salmon (*Oncorhynchus spp.*). Pages 273-286 in W.G. Pearcy (ed.), The influence of oceanic conditions on the production of salmonids in the north Pacific - A workshop. Oregon State Univ. Sea Grant College Program, ORESU-W-83-001.

Tenore, K.R. 1977. Food chain pathways in detrital feeding communities: A review, with new observations on sediment resuspension and detrital recycling. Pages 37 - 52 in B.C. Coull (ed.), Ecology of Marine Benthos, University of South Carolina Press, SC., USA.

USDA Soil Conservation Service and Eel River Resource Conservation District. 1989. The Salt River watershed workplan, including the lower Eel River, Delta, and Estuary workplan. Draft. The Eel River Resource Conservation District, Ferndale, CA. 39pp.

Wilkinson, L. 1988. Systat: The system for statistics. Systat Inc. Evanston, IL. 822pp.

Wood, C.C. 1987a. Predation of juvenile Pacific salmon by the common merganser (*Mergus merganser*) on eastern Vancouver Island. I: Predation during seaward migration. Canadian Journal of Fisheries and Aquatic Sciences. 44:941-949.

Wood, C.C. 1987b. Predation of juvenile Pacific salmon by the common merganser (*Mergus merganser*) on eastern Vancouver Island. II: Predation of stream resident juvenile salmon by merganser broods. Canadian Journal of Fisheries and Aquatic Sciences. 44:950-959.

Young, D.A. 1987. Juvenile chinook salmon abundance, growth, production and food habits in the Mattole River lagoon, California. MS Thesis, Humboldt State University, Arcata, CA. 73pp.

Zar, J.H. 1984. Biostatistical Analysis. 2nd ed. Prentice-Hall, INC. Englewood Cliffs, NJ. 718 pp.

Zedonis, P.A. and R.A. Barnhart. 1989. Biological parameters and juvenile salmonid populations (emphasis on steelhead), Mattole River Lagoon, California, July to October 1988. Summary Report. Bureau of Land Management, Arcata, CA. 42 pp.

Appendix A. List of Epibenthic and Planktonic Macrofauna Collected During the 1986-1987 Study Periods, Mattole River Estuary/Lagoon, California. Taxonomic Sources: Smith and Carlton eds. (1975); Borror et al. (1981); Barnes (1980); Merritt and Cummins eds. (1984). (X - Designates Benthic, O - Planktonic, Collection).

Scientific Name	Common Name	June	July	Aug	Sept	Oct	1986	1987
I. Platyhelminthes	Flatworms							
Turbellaria								
Seriata								
Tricladia	Planarians	X			X		X	X
II. Nematoda	Roundworms			X	X	XO	X	XO
III. Annelida	Segmented worms							
Oligochaeta		X	XO	O	X	O	X	XO
Tubificida								
Tubificidae			O	O		X	O	X
IV. Mollusca	Molluscs							
Gastropoda	Snails, limpets				X		X	
Neogastropoda								
Olividae						O		O
Olivella biplicata					X		X	
V. Arthropoda								
Chelicerata	Chelicerates							
Arachnida	Spiders, mites, ticks			O		XO	O	XO
Acarina	Mites, ticks							
Hydracarina	Aqutic Mites	O	XO	XO	XO	XO	XO	XO

Appendix A. List of Epibenthic and Planktonic Macrofauna Collected During the 1986-1987 Study Periods, Mattole River Estuary/Lagoon, California. Taxonomic Sources: Smith and Carlton eds. (1975); Borror et al. (1981); Barnes (1980); Merritt and Cummins eds. (1984). (X - Designates Benthic, O - Planktonic, Collection) (continued).

Scientific Name	Common Name	June	July	Aug	Sept	Oct	1986	1987
Crustacea	Crustaceans							
Ostracoda	Seed Shrimp		O	X	X		XO	XO
Copepoda	Copepods							
Calanoida								
Acartia clausi						O	O	
Cyclopoida								
Cyclops sp.			O	XO	XO	O	XO	XO
Malacostraca								
Mysidacea								
Mysidae	Opossum Shrimp							
Neomysis mercedis		O	O	XO	O	XO	XO	O
Isopoda	Isopods							
Sphaeromatidae								
Gnorimosphaeroma oregoniensis		XO	XO	XO	XO	XO	XO	XO
Oniscidae								
Poricello sp.					O			O
Amphipoda	Amphipods							
Corophiidae								
Corophium spinicorne		XO	XO	XO	XO	XO	XO	XO

Appendix A. List of Epibenthic and Planktonic Macrofauna Collected During the 1986-1987 Study Periods, Mattole River Estuary/Lagoon, California. Taxonomic Sources: Smith and Carlton eds. (1975); Borror et al. (1981); Barnes (1980); Merritt and Cummins eds. (1984). (X - Designates Benthic, O - Planktonic, Collection) (continued).

Scientific Name	Common Name	June	July	Aug	Sept	Oct	1986	1987
Gammaridae								
Eogammarus confervicolus			XO	XO	XO	XO	XO	XO
Insecta	Insects							
Coleoptera	Beetles		O			O	O	O
Chrysomelidae			X					X
Dytiscidae			O	O		O		O
Oreodytes sp.			O	XO	X		XO	XO
Elmidae			O				O	
Heterlimnius sp.			X	X	XO	O	X	XO
Zaitzevia sp.			X	X	XO	XO	X	XO
Hydrophilidae			X	O		O		XO
Diptera	True Flies		XO	XO	XO	XO	XO	XO
Chironomidae	Midges		XO	O	XO	O	XO	XO
Culicidae	Mosquitos				XO	O	XO	XO
Simmulidae	Riffle Flies		O		X		XO	X
Tipulidae	Crane Flies		XO		XO		X	XO
Ephemeroptera	Mayflies							
Baetidae								
Baetis sp.			XO	O	O	O	X	O

Appendix A. List of Epibenthic and Planktonic Macrofauna Collected During the 1986-1987 Study Periods, Mattole River Estuary/Lagoon, California. Taxonomic Sources: Smith and Carlton eds. (1975); Borror et al. (1981); Barnes (1980); Merritt and Cummins eds. (1984). (X - Designates Benthic, O - Planktonic, Collection) (continued).

Scientific Name	Common Name	June	July	Aug	Sept	Oct	1986	1987
Ephemerellidae								
Serratella sp.			X				X	
Heptageniidae								
Stenonema sp					O			O
Leptophelebiidae								
Paraleptophlebia sp.			X	X	X		X	X
Siphlonuridae								
Isonychia sp.					X		X	
Tricorythidae								
Tricorythodes sp.			X	X	XO	O	X	XO
Hemiptera	True Water-							
Corixidae	Bugs					XO		XO
Nacouridae								
Pelocris sp.			XO	XO	XO	O	XO	XO
Homoptera								
Cicadellidae	Cicads		XO	O			O	XO
Hymenoptera	Bees, Wasps,							
Formicidae	Ants		O			O	O	O
Megaloptera	Dobsonflies,							
Sialidae	Alderflies							
Sialis sp.			X	XO	XO		XO	XO

Appendix A. List of Epibenthic and Planktonic Macrofauna Collected During the 1986-1987 Study Periods, Mattole River Estuary/Lagoon, California. Taxonomic Sources: Smith and Carlton eds. (1975); Borror et al. (1981); Barnes (1980); Merritt and Cummins eds. (1984). (X - Designates Benthic, O - Planktonic, Collection) (continued).

Scientific Name	Common Name	June	July	Aug	Sept	Oct	1986	1987
Odonata								
Zygoptera	Damsel Flies							
Calopterygidae								
Hetaerina sp.			O				O	
Anisoptera	Dragonflies							
Aeshnidae								
Anax sp.			O					O
Plecoptera	Stoneflies							
Capniidae								
Capnia sp.				X	X	XO	X	XO
Trichoptera	Caddisflies							
Hydroptilidae								
Ithytrichia sp.			O				O	
Oxyethira sp.			XO	XO	O	XO	XO	XO
Lepidostomatidae								
Lepidostoma sp.				X	X	X	X	X
Limnephilidae								
Dicosmecus sp.			X					X
Sericostomatidae								
Gumaga griseus		XO	XO	XO	XO	XO	XO	XO

Appendix A. List of Epibenthic and Planktonic Macrofauna Collected During the 1986-1987 Study Periods, Mattole River Estuary/Lagoon, California. Taxonomic Sources: Smith and Carlton eds. (1975); Borror et al. (1981); Barnes (1980); Merritt and Cummins eds. (1984). (X - Designates Benthic, O - Planktonic, Collection) (continued).

Scientific Name	Common Name	June	July	Aug	Sept	Oct	1986	1987
VI. Vertebrata								
Osteichthyes								
Gasterosteiformes								
Gasterosteidae								
Gasterosteus aculeatus	Threespine Stickleback		O	O	O	XO	O	XO
Scorpaeniformes								
Cottidae								
Cottus asper	Prickly Sculpin	O						O

Appendix B. Numbers of Epibenthic Organisms Listed by Taxon and Collection Date, Ekman Grabs, 1986 Lower Mattole River Estuary/Lagoon.

	DATE				
Taxon	Jun 27	Jul 2	Jul 25	Aug 26	Oct 27
Amphipoda	309	400	434	159	52
Copepoda	0	0	0	6	0
Isopoda	0	7	111	68	41
Mysidacea	0	0	0	5	0
Coleoptera	0	0	1	0	0
Diptera	0	7	16	31	0
Ephemeroptera	0	0	1	0	0
Trichoptera	37	10	15	0	0
Hydracarina	0	28	1	4	0
Annelida	25	0	0	0	0
Platyhelminthes	4	0	0	0	0
Total	375	452	579	273	93

Taxon	Total	%	Mean	SD	SE
Amphipoda	1354	76.4	271	145	65
Copepoda	6	0.3	1	2	1
Isopoda	227	12.8	45	41	18
Mysidacea	5	0.3	1	2	1
Coleoptera	1	0.1	0	0	0
Diptera	54	3.0	11	12	5
Ephemeroptera	1	0.1	0	0	0
Trichoptera	62	3.5	12	14	6
Hydracarina	33	1.9	7	11	5
Annelida	25	1.4	5	10	4
Platyhelminthes	4	0.2	1	2	1
All Taxa/N=5 Sampling Dates	1772	100	354	165	74

Appendix C. Numbers of Epibenthic Organisms Listed by Taxon and Collection Date, Ekman Grabs, 1986 Upper Mattole River Estuary/Lagoon.

	DATE				
Taxon	Jun 27	Jul 02	Jul 25	Aug 26	Oct 27
Amphipoda	53	58	169	512	58
Copepoda	0	0	0	3	0
Isopoda	6	2	18	260	46
Mysidacea	0	0	0	6	1
Diptera	0	4	3	136	0
Ephemeroptera	0	8	7	4	0
Hemiptera	0	0	0	1	0
Megaloptera	0	2	0	0	0
Trichoptera	0	61	57	0	0
Total	59	135	254	922	105

Taxon	Total	%	Mean	SD	SE
Amphipoda	850	57.6	170	176	79
Copepoda	3	0.2	1	1	1
Isopoda	332	22.5	66	98	44
Mysidacea	7	0.5	1	2	1
Diptera	143	9.7	29	54	24
Ephemeroptera	19	1.3	4	3	2
Hemiptera	1	0.1	0	0	0
Megaloptera	2	0.1	0	1	0
Trichoptera	118	8.0	24	29	13
All Taxa/N=5 Sampling Dates	1475	100.0	295	320	143

Appendix D. Estimated Densities of Epibenthic Organisms Listed By Taxon, Collected During Bucket Type Substrate Sampler Pilot Study 1986, Upper Mattole Estuary/Lagoon. Estimates based on Sampler Surface Area of 0.0355 m .

Taxon	Total	%	Mean	SD	SE
Amphipoda	150388	48.5	18798	3685	1228
Isopoda	52206	16.8	6526	1305	435
Ostracoda	10345	3.3	1293	779	260
Coleoptera	141	0.0	18	24	8
Diptera	51698	16.7	6462	1941	647
Ephemeroptera	1409	0.5	176	105	35
Hemiptera	169	0.1	21	31	10
Megaloptera	169	0.1	21	19	6
Plecoptera	254	0.1	32	26	9
Trichoptera	40536	13.1	5067	2279	760
Gastropoda	113	0.0	14	20	7
Hydracarina	2368	0.8	296	193	64
Nematoda	141	0.0	18	24	8
Oligochaeta	56	0.0	7	12	4
Platyhelminthes	113	0.0	14	28	9
All Taxa/N=8 Sampling Units	310106	100	38763	5655	1999

Appendix E. Estimated Densities and Biomasses of Epibenthic Organisms Listed By Taxon. Bucket Type Substrate Sampler July 1987, Lower Mattole Estuary/Lagoon. Estimates based on Sampler Surface Area of 0.0355 m .

DENSITY (#/m)

Taxon	Total	%	Mean	SD	SE
Amphipods	733	18.4	244	70	41
Isopods	28	0.7	9	13	8
Coleoptera	28	0.7	9	13	8
Diptera	169	4.3	56	40	23
Trichoptera	2960	74.5	987	679	392
Oligochaeta	28	0.7	9	13	8
Terrestrials	28	0.7	9	13	8
All Taxa/N=3 Sampling Units	3975	100	1325	770	16

BIOMASS (grams dry weight/m)

Taxon	Total	%	Mean	SD	SE
Amphipods	0.2255	13.0	0.0752	0.0296	0.0171
Isopods	0.0169	1.0	0.0056	0.0080	0.0046
Coleoptera	0.0028	0.2	0.0009	0.0013	0.0008
Diptera	0.0564	3.3	0.0188	0.0035	0.0020
Trichoptera	1.4264	82.3	0.4755	0.3225	0.1862
Oligochaeta	0	0	0	0	0
Terrestrials	0.0056	0.3	0.0019	0.0027	0.0015
All Taxa/N=3 Sampling Units	1.7336	100	0.57787174	0.36158744	0.20876261

Appendix F. Estimated Densities and Biomasses of Epibenthic Organisms Listed By Taxon. Bucket Type Substrate Sampler August 1987, Lower Mattole Estuary/Lagoon. Estimates based on Sampler Surface Area of 0.0355 m .

DENSITY (#/m)

Taxon	Total	%	Mean	SD	SE
Amphipods	8259	82	2065	1590	795
Isopods	1381	14	345	251	125
Diptera	197	2	49	58	29
Trichoptera	141	1	35	46	23
Nematode	113	1	28	35	17
Oligochaete	28	0	7	12	6
All Taxa/N=4 Sampling Units	10120	100	2530	1807	903

Biomass (grams dry weight/m)

Taxon	Total	%	Mean	SD	SE
Amphipods	3.8168	73.1	1.0843	0.8869	0.5121
Isopods	1.1642	22.3	0.3364	0.2705	0.1562
Diptera	0.0338	0.6	0.0113	0.0080	0.0046
Trichoptera	0.1917	3.7	0.0536	0.0757	0.0437
Nematode	0.0113	0.2	0.0028	0.0040	0.0023
Oligochaeta	0	0	0	0	0
All Taxa/N=4 Sampling Units	5.21775899	100	1.3044	0.90019714	0.45009857

Appendix G. Estimated Densities and Biomasses of Epibenthic Organisms Listed By Taxon. Bucket Type Substrate Sampler September 1987, Lower Mattole Estuary/Lagoon. Estimates based on Sampler Surface Area of 0.0355 m .

DENSITY (#/m)

Taxon	Total	%	Mean	SD	SE
Amphipods	3101	63.2	775.2	602	301
Isopods	1381	28.2	345.3	233	19
Coleoptera	28	0.6	7.0	12	3
Diptera	197	4.0	49.3	31	7
Trichoptera	169	3.4	42.3	24	7
Platyhelminthes	28	0.6	7.0	12	3
All Taxa/N=4 Sampling Units	4905	100.0	1226.0	816	408

Biomass (grams dry weight/m)

Taxon	Total	%	Mean	SD	SE
Amphipods	3.4278	66.5	0.8569	1.0246	0.9257
Isopods	1.3643	26.5	0.3411	0.2287	0.5840
Coleoptera	0.0056	0.1	0.0014	0.0024	0.0375
Diptera	0.1156	2.2	0.0289	0.0241	0.1700
Trichoptera	0	4.2	0.1	0	0
Platyhelminthes	0	0.0	0.0	0	0
All Taxa/N=4 Sampling Units	5	99.6	1.3	1	1

Appendix H. Estimated Densities and Biomasses of Epibenthic Organisms Listed By Taxon. Bucket Type Substrate Sampler October 1987, Lower Mattole Estuary/Lagoon. Estimates based on Sampler Surface Area of 0.0355 m .

DENSITY (#/m)

Taxon	Total	%	Mean	SD	SE
Amphipods	18013	74.2	4503	1366	683
Isopods	3242	13.4	810	164	82
Diptera	56	0.2	14	14	7
Trichoptera	1889	7.8	472	325	162
Hydracarina	56	0.2	14	14	7
Oligochaete	987	4.1	247	181	90
Osteichthys	28	0.1	7	12	6
All Taxa/N=4 Sampling Units	24271	100	6068	1201	601

Biomass (grams dry weight/m)

Taxon	Total	%	Mean	SD	SE
Amphipods	4.7555	58.3	1.1889	0.3544	0.1772
Isopods	1.5927	19.5	0.3982	0.1390	0.0695
Diptera	0.0282	0.3	0.0070	0.0073	0.0037
Trichoptera	0.5835	7.2	0.1459	0.0707	0.0353
Hydracarina	0.0085	0.1	0.0021	0.0037	0.0018
Oligochaete	0.1128	1.4	0.0282	0.0270	0.0135
Osteichthys	1.0712	13.1	0.2678	0.4638	0.2319
All Taxa/N=4 Sampling Units	8.1522	100	2.0381	0.5825	0.2913

Appendix I. Estimated Densities and Biomasses of Epibenthic Organisms Listed by Taxon. Bucket Type Substrate Sampler July 1987, Upper Mattole Estuary/Lagoon. Estimates Based on Sampler Surface Area of 0.0355 m .

	DENSITY (#/m)					BIOMASS (grams dry weight/m)				
Taxon	Total	%	Mean	SD	SE	Total	%	Mean	SD	SE
Amphipoda	16801	55.3	5600	2915	60	6.0973	43.5	2.0324	0.9922	0.5728
Isopoda	1832	6.0	611	455	9	0.4848	3.5	0.1616	0.0791	0.0457
Ostracoda	282	0.9	94	70	1	0.0056	0.0	0.0019	0.0013	0.0008
Coleoptera	85	0.3	28	23	0	0.0169	0.1	0.0056	0.0061	0.0035
Diptera	6963	22.9	2321	1526	881	0.9020	6.4	0.3007	0.1679	0.0969
Hemiptera	28	0.1	9	13	0	0.1325	0.9	0.0442	0.0625	0.0361
Megaloptera	28	0.1	9	13	0	0.0056	0.0	0.0019	0.0027	0.0015
Trichoptera	3016	9.9	1005	457	9	6.1593	43.9	2.0531	0.4602	0.2657
Hydracarina	733	2.4	244	185	4	0.0592	0.4	0.0197	0.0115	0.0066
Nematoda	366	1.2	122	93	2	0.0197	0.1	0.0066	0.0048	0.0028
Oligochaeta	113	0.4	38	53	1	0.0085	0.1	0.0028	0.0040	0.0023
Terrestrials	113	0.4	38	35	1	0.1240	0.9	0.0413	0.0565	0.0326
All Taxa/N=4 Sampling Units	30359	100	10120	5594	3230	14.016	100	4.6718	0.9549	0.5513

Appendix J. Estimated Densities and Biomasses of Epibenthic Organisms Listed by Taxon. Bucket Type Substrate Sampler August 1987, Upper Mattole Estuary/Lagoon. Estimates Based on Sampler Surface Area of 0.0355 m .

Taxon	DENSITY (#/m) Total	%	Mean	SD	SE	BIOMASS (grams dry weight/m) Total	%	Mean	SD	SE
Amphipoda	30669	46	7667	2051	1026	20.9161	50.8	5.2290	1.3141726	0.6571
Copepoda	28	0	7	12	6	0.0000	0.0	0.0000	0.0000	0.0000
Isopoda	13841	21	3460	1367	683	13.3897	32.5	3.3474	1.4744319	0.7372
Ostracoda	620	1	155	142	71	0.0113	0.0	0.0028	0.0034524	0.0017
Coleoptera	254	0	63	78	39	0.0536	0.1	0.0134	0.0168398	0.0084
Diptera	15814	24	3953	1398	699	2.3650	5.7	0.5913	0.1528239	0.0764
Ephemeroptera	56	0	14	24	12	0.0113	0.0	0.0028	0.0048825	0.0024
Hemiptera	113	0	28	49	24	0.3946	1.0	0.0987	0.1708859	0.0854
Megaloptera	85	0	21	12	6	0.2171	0.5	0.0543	0.0382048	0.1910
Plecoptera	85	0	21	12	6	0.0085	0.0	0.0021	0.0012204	0.0006
Trichoptera	1268	2	317	203	101	3.6786	8.9	0.9197	0.524905	0.2625
Hydracarina	733	1	183	128	64	0.0507	0.1	0.0127	0.0080966	0.0040
Nematoda	1917	3	479	202	101	0.0395	0.1	0.0099	0.0031516	0.0016
Oligochaeta	846	1	211	108	54	0.0536	0.1	0.0134	0.0067226	0.0034
Terrestrials	56	0	14	14	7	0.0056	0.0	0.0014	0.0014	0.0007
All Taxa/N=4 Sampling Units	66385	100	16596	4394	2197	41.1952	100	10.299	2.3066	1.1533

Appendix K. Estimated Densities and Biomasses of Epibenthic Organisms Listed by Taxon. Bucket Type Substrate Sampler September 1987, Upper Mattole Estuary/Lagoon. Estimates Based on Sampler Surface Area of 0.0355 m .

	DENSITY (#/m)					BIOMASS (grams dry weight/m)				
Taxon	Total	%	Mean	SD	SE	Total	%	Mean	SD	SE
Amphipoda	17505	51.5	4376	2214	1107	14.5455	38.4	3.6364	1.6438	0.8219
Isopoda	8879	26.1	2220	748	374	12.5046	33.0	3.1261	1.3109	0.6554
Ostracoda	28	0.1	7	12	6	0.0000	0.0	0.0000	0.0000	0.0000
Coleoptera	28	0.1	7	12	6	0.0085	0.0	0.0021	0.0037	0.0018
Diptera	4031	11.9	1008	76	38	2.9852	7.9	0.7463	0.2918	0.1459
Ephemeroptera	85	0.2	21	23	12	0.0677	0.2	0.0169	0.0179	0.0090
Megaloptera	28	0.1	7	12	6	0.2791	0.7	0.0698	0.1208	0.0604
Plecoptera	451	1.3	113	56	28	0.0395	0.1	0.0099	0.0032	0.0016
Trichoptera	1832	5.4	458	67	34	7.3939	19.5	1.8485	0.4795	0.2397
Hydracarina	310	0.9	78	78	39	0.0282	0.0	0.0070	0.0073	0.0037
Nematoda	817	2.4	204	167	84	0.0451	0.1	0.0113	0.0053	0.0026
All Taxa/N=4 Sampling Units	33996	100	8499	2447	1224	37.8971	100	9.4743	2.6774	1.3387

Appendix L. Estimated Densities and Biomasses of Epibenthic Organisms Listed by Taxon. Bucket Type Substrate Sampler October 1987, Upper Mattole Estuary/Lagoon. Estimates Based on Sampler Surface Area of 0.0355 m .

	DENSITY (#/m)					BIOMASS (grams dry weight/m)				
Taxon	Total	%	Mean	SD	SE	Total	%	Mean	SD	SE
Amphipoda	16434	20.2	4109	3025	1513	4.0000	9.4	1.5053	1.1356	0.5678
Isopoda	1043	1.3	261	134	67	1.1219	1.8	0.2805	0.1636	0.0818
Coleoptera	28	0.0	7	12	6	0.0028	0.0	0.0007	0.0012	0.0006
Diptera	761	0.9	190	102	51	1.3531	2.1	0.3383	0.3103	0.1552
Trichoptera	1438	1.8	359	81	40	6.7766	10.6	1.6942	0.3864	0.1932
Hydracarina	28	0.0	7	12	6	0.0000	0.0	0.0000	0.0000	0.0000
Oligochaeta	61649	75.7	15412	12512	6256	48.4764	76.0	12.119	15.846	7.923
Terrestrials	28	0.0	7	12	6	0.0113	0.0	0.0028	0.0049	0.0024
All Taxa/N=4 Sampling Units	81409	100	20352	10516	5258	67.7632	100	15.941	15.041	7.5206

Appendix M. Numbers of Planktonic Organisms Listed by Taxon and Collection Date, 1986 Lower Mattole River Estuary/Lagoon.

	DATE					
Taxon	Jun 18	Jul 2	Jul 25	Aug 8	Aug 26	Sept 13
Amphipoda	1	2	641	106	577	457
Isopoda	0	1	1	2	14	79
Mysidacea	0	0	81	283	67	173
Ostracoda	0	0	2	0	0	0
Coleoptera	0	5	0	0	0	0
Diptera	0	1	4	19	62	81
Hemiptera	0	0	0	0	1	0
Trichoptera	3	0	0	0	0	0
Hydracarina	13	136	17	23	23	3
Oligochaeta	0	0	103	11	0	0
Osteichthyes	0	0	0	2	1	1
Terrestrials	0	0	0	2	1	0
Total	17	145	849	448	746	749

Taxon	Total	%	Mean	SD	SE
Amphipoda	1784	59.5	297	270	110
Isopoda	97	3.2	16	27	12
Mysidacea	604	20.1	101	99	41
Ostracoda	2	0.1	0	1	0
Coleoptera	5	0.2	1	2	1
Diptera	167	5.6	28	31	13
Hemiptera	1	0.0	0	0	0
Trichoptera	3	0.1	1	1	0
Hydracarina	215	7.2	36	44	19
Oligochaeta	114	3.8	19	36	15
Osteichthyes	4	0.1	1	1	0
Terrestrials	3	0.1	1	1	0
All Taxa/N=6 Sampling Dates	2999	100.0	500	324	132

Appendix N. Numbers of Planktonic Organisms Listed by Taxon and Collection Date, 1986 Upper Mattole River Estuary/Lagoon.

	DATE					
Taxon	Jun 18	Jul 2	Jul 25	Aug 8	Aug 26	Sept 13
Amphipoda	3	0	246	12	67	619
Copepoda	0	0	0	0	2	2
Isopoda	1	0	4	0	26	121
Mysidacea	5	0	34	26	1264	641
Coleoptera	0	7	2	0	0	0
Diptera	0	6	6	20	220	155
Hemiptera	0	0	5	0	3	3
Megaloptera	0	0	0	0	1	0
Odonata	0	0	1	0	0	0
Trichoptera	52	2	0	0	0	0
Hydracarina	21	266	36	3	486	16
Osteichthyes	1	0	1	0	0	0
Terrestrials	0	2	0	1	1	0
Total	83	283	335	62	2070	1557

Taxon	Total	%	Mean	SD	SE
Amphipoda	944	21.5	158	223	91
Copepoda	4	0.1	1	1	0
Isopoda	151	3.4	25	44	18
Mysidacea	1965	44.8	328	477	195
Coleoptera	9	0.2	2	3	1
Diptera	407	9.3	68	87	35
Hemiptera	11	0.3	2	2	1
Megaloptera	1	0.0	0	0	0
Odonata	1	0.0	0	0	0
Trichoptera	2	0.0	9	19	8
Hydracarina	807	18.4	138	180	74
Osteichthyes	1	0.0	0	0	0
Terrestrials	4	0.1	1	1	0
All Taxa/N=6 Sampling Dates	4390	732.0	732	785	320

Appendix O. Estimated Concentrations of Planktonic Organisms Listed by Taxon and Collection Date, 1987 Lower Mattole River Estuary/Lagoon, Daytime. Estimates Based on Volume Filtered in Cubic Meters.

	DATE				
Taxon	Jul 7	Aug 9	Sep 9	Oct 7	
Amphipoda	0	0.05	0.81	0.59	
Copepoda	0.03	2.21	0.30	0.89	
Isopoda	0.03	0	0.43	0.20	
Mysidacea	0	0	0.30	0	
Ostracoda	0	0	0.08	12.16	
Coleoptera	0.34	0.05	0.03	0.10	
Diptera	0.4	0.22	1.33	0.15	
Ephemeroptera	0	0	0.11	0	
Hemiptera	0	0	0.03	0	
Plecoptera	0	0	0	0.05	
Trichoptera	0.16	0	0	0.05	
Hydracarina	0.32	0.89	0.46	2.17	
Oligochaeta	0.03	0	0	0	
Terrestrials	0.03	0	0	0	
Total	1.32	3.42	3.87	16.34	
Volume Filtered	37.97	37.11	36.97	20.32	
Taxon	Total	%	Mean	SD	SE
Amphipoda	1.45	5.8	0.36	0.35	0.17
Copepoda	3.43	13.7	0.86	0.84	0.42
Isopoda	0.66	2.6	0.17	0.17	0.86
Mysidacea	0.3	1.2	0.08	0.13	0.64
Ostracoda	12.24	49.1	3.06	5.25	2.62
Coleoptera	0.52	2.1	0.13	0.12	0.06
Diptera	2.1	8.4	0.53	0.47	0.24
Ephemeroptera	0.11	0.4	0.03	0.05	0.02
Hemiptera	0.03	0.1	0.01	0.01	0.01
Plecoptera	0.05	0.2	0.01	0.02	0.01
Trichoptera	0.21	0.8	0.05	0.07	0.03
Hydracarina	3.84	15.4	0.96	0.73	0.36
Oligochaeta	0.03	0.1	0.01	0.01	0.01
Terrestrials	0.03	0.1	0.01	0.01	0.01
All Taxa/N=4 Sampling Dates	24.95	100.0	6.24	8.24	5.46

Appendix P. Estimated Biomasses of Planktonic Organisms Listed by Taxon and Collection Date, 1987 Lower Mattole River Estuary/Lagoon, Daytime. Estimates Based on Volume Filtered. Grams Dry Wt./m .

Taxon	DATE Jul 7	Aug 9	Sep 9	Oct 7
Amphipoda	0.0000	0.0000	0.0001	0.0002
Copepoda	0.0000	0.0000	0.0000	0.0000
Isopoda	0.0000	0.0000	0.0001	0.0003
Mysidacea	0.0000	0.0000	0.0003	0.0000
Ostracoda	0.0000	0.0000	0.0000	0.0003
Coleoptera	0.0001	0.0000	0.0000	0.0000
Diptera	0.0000	0.0000	0.0001	0.0000
Hemiptera	0.0000	0.0000	0.0000	0.0000
Plecoptera	0.0000	0.0000	0.0000	0.0000
Trichoptera	0.0001	0.0000	0.0000	0.0000
Hydracarina	0.0000	0.0001	0.0001	0.0003
Oligochaeta	0.0000	0.0000	0.0000	0.0000
Terrestrials	0.0000	0.0000	0.0000	0.0000
Total	0.0003	0.0001	0.0007	0.0012
Volume Filtered	37.97	37.11	36.97	20.32

Taxon	Total	%	Mean	SD	SE
Amphipoda	0.0003	15.0	0.0001	0.0001	0.0000
Copepoda	0.0001	2.6	0.0000	0.0000	0.0000
Isopoda	0.0005	21.4	0.0001	0.0001	0.0001
Mysidacea	0.0003	11.5	0.0001	0.0001	0.0001
Ostracoda	0.0003	14.5	0.0001	0.0001	0.0001
Coleoptera	0.0001	5.1	0.0000	0.0000	0.0000
Diptera	0.0001	5.9	0.0000	0.0000	0.0000
Hemiptera	0.0000	1.0	0.0000	0.0000	0.0000
Plecoptera	0.0000	0.2	0.0000	0.0000	0.0000
Trichoptera	0.0001	4.4	0.0000	0.0000	0.0000
Hydracarina	0.0004	17.5	0.0001	0.0001	0.0000
Oligochaeta	0.0000	0.1	0.0000	0.0000	0.0000
Terrestrials	0.0000	0.9	0.0000	0.0000	0.0000
All Taxa/N=4 Sampling Dates	0.0023	100.0	0.0006	0.0004	0.0002

Appendix Q. Estimated Concentrations of Planktonic Organisms Listed by Taxon and Collection Date, 1987 Lower Mattole River Estuary/Lagoon, Nighttime. Estimates Based on Volume Filtered in Cubic Meters.

	DATE			
Taxon	Jul 7	Aug 9	Sep 9	Oct 7
Amphipoda	3.29	3.71	7.41	0.24
Copepoda	0.83	172.28	555.23	34.93
Isopoda	0.06	2.82	2.25	0.71
Mysidacea	0	0	3.22	0
Ostracoda	0.03	0.15	0.64	0.08
Coleoptera	0	0.89	0	0.32
Diptera	0.97	25.06	8.05	6.87
Ephemeroptera	0.22	0	0	0
Trichoptera	0.17	0	0	0
Hydracarina	0.72	2.52	6.76	0.32
Oligochaeta	0	0	0	0.08
Osteichthyes	0.06	0.15	0	0
Total	6.32	207.56	583.57	43.54
Volume Filtered	36.21	13.49	6.21	25.31

Taxon	Total	%	Mean	SD	SE
Amphipoda	14.65	1.7	3.66	2.54	1.27
Copepoda	763.27	90.8	190.82	219.96	109.98
Isopoda	5.84	0.7	1.46	1.12	0.56
Mysidacea	3.22	0.4	0.81	1.39	0.70
Ostracoda	0.9	0.1	0.23	0.24	0.12
Coleoptera	1.21	0.1	0.30	0.36	0.18
Diptera	40.95	4.9	10.24	8.97	4.48
Ephemeroptera	0.22	0.0	0.06	0.10	0.05
Trichoptera	0.17	0.0	0.04	0.07	0.04
Hydracarina	10.32	1.2	2.58	2.55	1.28
Oligochaeta	0.08	0.0	0.02	0.03	0.02
Osteichthyes	0.21	0.0	0.05	0.06	0.03
All Taxa/N=4 Sampling Dates	841	100.0	210.00	228.00	5.80

Appendix R. Estimated Biomasses of Planktonic Organisms Listed by Taxon and Collection Date, 1987 Lower Mattole River Estuary/Lagoon, Nighttime. Estimates Based on Volume Filtered. Grams Dry Wt./m .

	DATE			
Taxon	Jul 7	Aug 9	Sep 9	Oct 7
Amphipoda	0.0000	0.0000	0.0004	0.0000
Copepoda	0.0000	0.0014	0.0047	0.0004
Isopoda	0.0000	0.0001	0.0003	0.0000
Mysidacea	0.0000	0.0000	0.0001	0.0000
Ostracoda	0.0000	0.0000	0.0000	0.0000
Coleoptera	0.0000	0.0001	0.0000	0.0000
Diptera	0.0001	0.0007	0.0004	0.0002
Ephemeroptera	0.0000	0.0000	0.0000	0.0000
Hydracarina	0.0000	0.0002	0.0008	0.0000
Osteichthyes	0.0001	0.000266	0.0000	0.0000
Total	0.0003	0.0028	0.0068	0.0007
Volume Filtered	36.21	13.49	6.21	25.31

Taxon	Total	%	Mean	SD	SE
Amphipoda	0.0005	4.6	0.0001	0.0002	0.0001
Copepoda	0.0065	62.1	0.0016	0.0019	0.0009
Isopoda	0.0004	4.0	0.0001	0.0001	0.0001
Mysidacea	0.0001	1.2	0.0000	0.0001	0.0000
Ostracoda	0.0000	0.3	0.0000	0.0000	0.0000
Coleoptera	0.0002	1.8	0.0000	0.0001	0.0000
Diptera	0.0012	11.9	0.0003	0.0002	0.0001
Ephemeroptera	0.0000	0.1	0.0000	0.0000	0.0000
Hydracarina	0.0011	10.2	0.0003	0.0003	0.0002
Osteichtheys	0.0004	3.6	0.0001	0.0001	0.0001
All Taxa/N=4 Sampling Dates	0.0105	100.0	0.0006	0.0004	0.0002

Appendix S. Estimated Concentrations of Planktonic Organisms Listed by Taxon and Collection Date, 1987 Upper Mattole River Estuary/Lagoon, Daytime. Estimates Based on Volume Filtered in Cubic Meters.

	DATE			
Taxon	Jul 7	Aug 9	Sep 9	Oct 7
Amphipoda	0	0.05	36.11	0.90
Copepoda	0.03	0	7.34	0.50
Isopoda	0	0	97.82	2.41
Ostracoda	0	0.03	19.64	42.19
Coleoptera	0.03	0	0.99	0.00
Diptera	0.05	0.3	109.52	8.64
Ephemeroptera	0	0.03	0.99	0.40
Hemiptera	0	0	1.19	0.2
Megaloptera	0	0	0.20	0
Trichoptera	0	0.08	18.05	14.87
Gastropoda	0	0	0	1.41
Hydracarina	0.08	0.24	24.01	5.52
Nematoda	0	0	0	0.30
Oligochaeta	0	0.24	0	0
Osteichthyes	0	0	0.20	0
Terrestrials	0.08	0	0	0
Total	0.26	0.97	316.07	77.35
Volume Filtered	38.09	37.91	10.08	19.91

Taxon	Total	%	Mean	SD	SE
Amphipoda	37.06	9.4	9.27	15.50	7.75
Copepoda	7.87	2.0	1.97	3.11	1.55
Isopoda	100.23	25.4	25.06	42.02	21.01
Ostracoda	61.86	15.7	15.47	17.39	8.69
Coleoptera	1.02	0.3	0.26	0.42	0.21
Diptera	118.51	30.0	29.63	46.26	23.13
Ephemeroptera	1.42	0.4	0.36	0.40	0.20
Hemiptera	1.39	0.4	0.35	0.49	0.25
Megaloptera	0.2	0.1	0.05	0.09	0.04
Trichoptera	33	8.4	8.25	8.29	4.14
Gastropoda	1.41	0.4	0.35	0.61	0.30
Hydracarina	29.85	7.6	7.46	9.80	4.90
Nematoda	0.3	0.1	0.08	0.13	0.652
Oligochaeta	0.24	0.1	0.06	0.10	0.05
Osteichthyes	0.2	0.1	0.05	0.09	0.04
Terrestrials	0.08	0.0202706	0.02	0.034641	0.02
All Taxa/N=4 Sampling Dates	394.66	100	98.66	129.37	64.68

Appendix T. Estimated Biomasses of Planktonic Organisms Listed by Taxon and Collection Date, 1987 Upper Mattole River Estuary/Lagoon, Daytime. Estimates Based on Volume Filtered. Grams Dry Wt./m .

	DATE			
Taxon	Jul 7	Aug 9	Sep 9	Oct 7
Amphipoda	0.0000	0.0000	0.0180	0.0000
Copepoda	0.0000	0.0000	0.0001	0.0000
Isopoda	0.0000	0.0000	0.0228	0.0016
Ostracoda	0.0000	0.0000	0.0005	0.0010
Coleoptera	0.0000	0.0000	0.0002	0.0000
Diptera	0.0000	0.0000	0.0070	0.0007
Ephemeroptera	0.0000	0.000002	0.00006	0.000231
Hemiptera	0.0000	0.0000	0.0002	0.0001
Megaloptera	0.0000	0.0000	0.0006	0.0000
Trichoptera	0.0000	0.0001	0.0006	0.0018
Gastropoda	0.0000	0.0000	0.0000	0.000241
Hydracarina	0.0000	0.0000	0.0017	0.0005
Oligochaeta	0.0000	0.0000	0.0000	0.0000
Osteichthyes	0.0000	0.0000	0.0003	0.0000
Terrestrials	0.0000	0.0000	0.0000	0.0001
Total	0.0000	0.0001	0.0520	0.0062
Volume Filtered	38.09	37.91	10.08	19.91

Taxon	Total	%	Mean	SD	SE
Amphipoda	0.0180	30.9	0.0045	0.0078	0.0039
Copepoda	0.0001	0.2	0.0000	0.0000	0.0000
Isopoda	0.0244	41.7	0.0061	0.0097	0.0048
Ostracoda	0.0014	2.4	0.0004	0.0004	0.0002
Coleoptera	0.0002	0.3	0.0000	0.0001	0.0000
Diptera	0.0078	13.4	0.0019	0.0029	0.0015
Ephemeroptera	0.0003	0.5	0.0001	0.0001	0.0000
Hemiptera	0.0003	0.6	0.0001	0.0001	0.0000
Megaloptera	0.0006	1.1	0.0002	0.0003	0.0001
Trichoptera	0.0025	4.2	0.0006	0.0007	0.0004
Gastropoda	0.0002	0.4	0.0001	0.0001	0.0001
Hydracarina	0.0022	3.7	0.0005	0.0007	0.0003
Oligochaeta	0.0000	0.0	0.0000	0.0000	0.0000
Osteichthyes	0.0003	0.5	0.0001	0.0001	0.0001
Terrestrials	0.0001	0.1	0.0000	0.0000	0.0000
All Taxa/N=4 Sampling Dates	0.0584	100.0	0.0146	0.0217	0.0109

Appendix U. Estimated Concentrations of Planktonic Organisms Listed by Taxon and Collection Date, 1987 Upper Mattole River Estuary/Lagoon, Nighttime. Estimates Based on Volume Filtered in Cubic Meters.

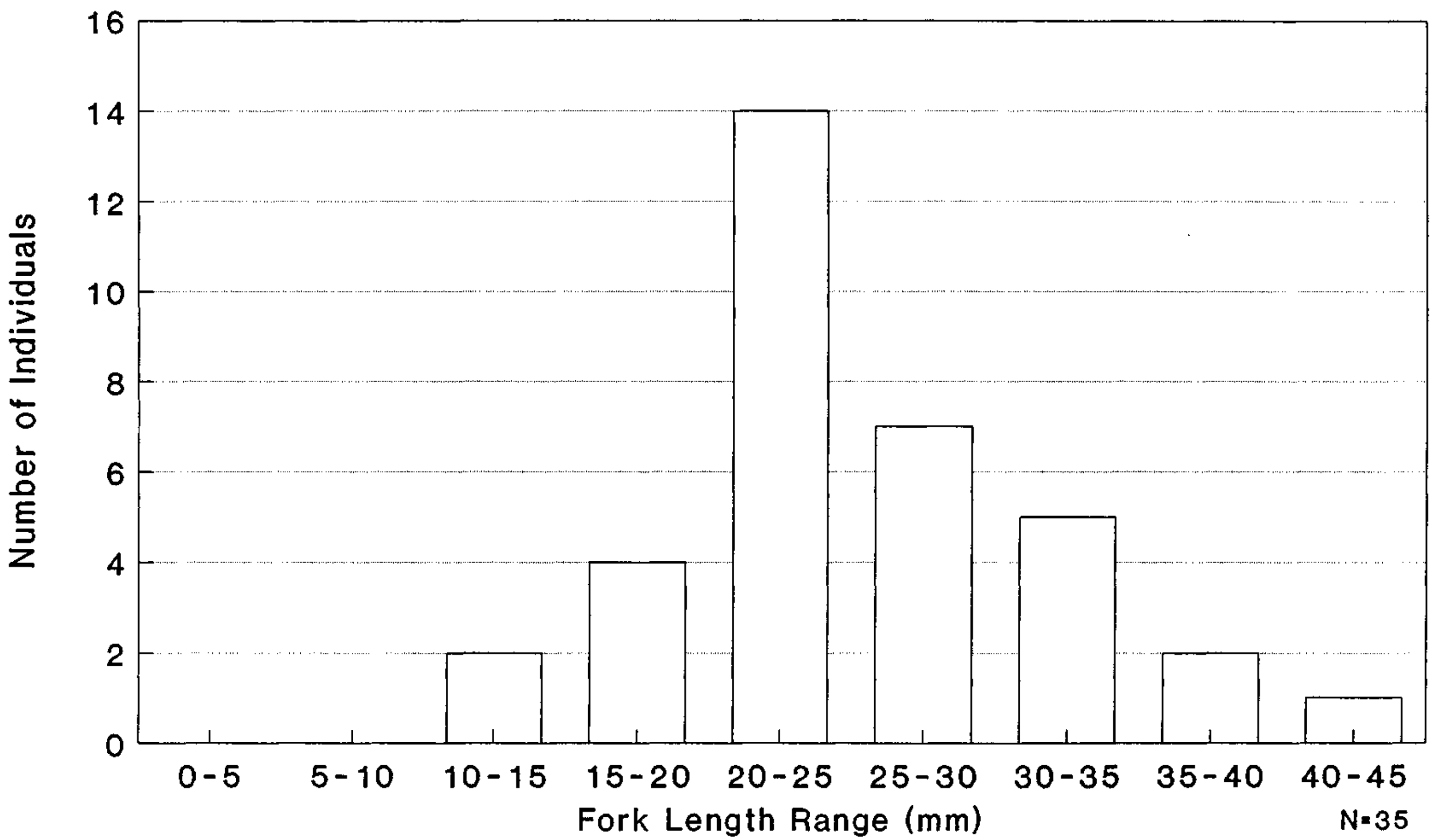
	DATE			
Taxon	Jul 7	Aug 9	Sep 9	Oct 7
Amphipoda	0.043	0.11	9.73	15.30
Copepoda	3.24	0.49	1.00	1.54
Isopoda	0.17	0.89	18.28	40.83
Mysidacea	0.03	0.03	0.04	1.85
Ostracoda	0.11	0.34	4.14	6.57
Coleoptera	0.06	0	0.22	0.22
Diptera	2.13	2.87	32.2	9.35
Ephemeroptera	0.65	0.26	1.57	0.88
Hemiptera	0	0.06	0.39	0.18
Odonata	0.03	0	0	0
Trichoptera	0.97	0.6	3.1	8.25
Hydracarina	0.80	1.35	4.89	5.95
Oligochaeta	0.99	3.99	0	0.71
Osteichthyes	0.14	0.11	0	1.54
Terrestrials	0	0	0.04	0
Total	9.74	11.12	75.61	93.17
Volume Filtered	35.2	34.81	22.92	22.68

Taxon	Total	%	Mean	SD	SE
Amphipoda	25.183	13.3	6.30	6.52	3.26
Copepoda	6.27	3.3	1.57	1.03	0.52
Isopoda	60.17	31.7	15.04	16.56	8.28
Mysidacea	1.95	1.0	0.49	0.79	0.39
Ostracoda	11.16	5.9	2.79	2.71	1.35
Coleoptera	0.5	0.3	0.13	0.10	0.05
Diptera	46.55	24.5	11.64	12.20	6.10
Ephemeroptera	3.36	1.8	0.84	0.48	0.24
Hemiptera	0.63	0.3	0.16	0.15	0.07
Odonata	0.03	0.0	0.01	0.01	0.01
Trichoptera	12.92	6.8	3.23	3.05	1.53
Hydracarina	12.99	6.8	3.25	2.21	1.11
Oligochaeta	5.69	3.0	1.42	1.53	0.76
Osteichthyes	1.79	0.9	0.45	0.63	0.32
Terrestrials	0.04	0.0	0.01	0.02	0.01
All Taxa/N=4 Sampling Dates	189.233	100.0	6.24	5.91	16.34

Appendix V. Estimated Biomasses of Planktonic Organisms Listed by Taxon and Collection Date, 1987 Upper Mattole River Estuary/Lagoon, Nighttime. Estimates Based on Volume Filtered. Grams Dry Wt./m .

	DATE			
Taxon	Jul 8	Aug 10	Sep 10	Oct 8
Amphipoda	0.0000	0.0000	0.0052	0.0033
Copepoda	0.0000	0.0000	0.0000	0.0001
Isopoda	0.0000	0.0000	0.0050	0.0219
Mysidacea	0.0000	0.00006	0.000044	0.001591
Ostracoda	0.0000	0.0000	0.0001	0.0003
Coleoptera	0.0000	0.0000	0.0001	0.0003
Diptera	0.0001	0.0002	0.0016	0.0007
Ephemeroptera	0.0000	0.000028	0.000467	0.000074
Hemiptera	0.0000	0.0000	0.0002	0.0003
Odonata	0.0000	0.0000	0.0000	0.0000
Trichoptera	0.0001	0.0001	0.0003	0.0028
Hydracarina	0.0000	0.0000	0.0003	0.0004
Oligochaeta	0.0000	0.0001	0.0000	0.0000
Osteichthyes	0.0001	0.0009	0.0000	1.1415
Terrestrials	0.0000	0.0000	0.0002	0.0000
Total	0.0005	0.0014	0.0134	1.1732
Volume Filtered	35.20	34.81	22.92	22.68

Taxon	Total	%	Mean	SD	SE
Amphipoda	0.0085	0.7	0.0021	0.0022	0.0011
Copepoda	0.0001	0.0	0.0000	0.0000	0.0000
Isopoda	0.0270	2.3	0.0068	0.0090	0.0045
Mysidacea	0.0017	0.1	0.0004	0.0007	0.0003
Ostracoda	0.0004	0.0	0.0001	0.0001	0.0001
Coleoptera	0.0003	0.0	0.0001	0.0001	0.0001
Diptera	0.0026	0.2	0.0006	0.0006	0.0003
Ephemeroptera	0.0006	0.1	0.0002	0.0002	0.0001
Hemiptera	0.0005	0.0	0.0001	0.0001	0.0001
Odonata	0.0000	0.0	0.0000	0.0000	0.0000
Trichoptera	0.0033	0.3	0.0008	0.0011	0.0006
Hydracarina	0.0008	0.1	0.0002	0.0002	0.0001
Oligochaeta	0.0001	0.0	0.0000	0.0000	0.0000
Osteichthyes	1.1424	96.0	0.2856	0.4941	0.2471
Terrestrials	0.0002	0.0	0.0000	0.0001	0.0000
All Taxa/N=4 Sampling Dates	1.1568	100.0016	0.2892	0.4921	0.0000



Appendix W. Length Frequency Histogram of Threespine Stickleback Collected in 0.5m, 333μ Mesh Plankton Net. Upper Mattole Lagoon, October. 1987.

Appendix X. List of Organisms Identified in the Stomachs of Juvenile Chinook Salmon Collected During the 1986-1987 Study Periods. Mattole River Estuary/Lagoon, California. Taxonomic Sources: Smith and Carlton eds.(1975); Borror et al. (1976); Barnes (1980); Merritt and Cummins eds. (1984).

Scientific Name	Common Name	June	July	Aug	Sept	1986	1987
I. Arthropoda							
Chelicerata	Chelicerates						
Arachnida	Spiders, mites, ticks	X	X			X	X
Acarina	Mites, ticks		X			X	
Hydracarina	Aqutic Mites	X		X			X
Crustacea	Crustaceans						
Ostracoda	Seed Shrimp						
Malacostraca							
Mysidacea	Opossum Shrimp						
Mysidae							
Neomysis mercedis			X	X		X	
Isopoda	Isopods						
Sphaeromatidae							
Gnorimosphaeroma oregoniensis		X	X	X	X	X	X
Amphipoda	Amphipods						
Corophiidae							
Corophium spinicorne		X	X	X	X	X	X

Appendix X. List of Organisms Identified in the Stomachs of Juvenile Chinook Salmon Collected During the 1986-1987 Study Periods. Mattole River Estuary/Lagoon, California. Taxonomic sources: Smith and Carlton eds. (1975); Borror et al. (1976); Barnes (1980); Merritt and Cummins eds. (1984)(continued).

Scientific Name	Common Name	June	July	Aug	Sept	1986	1987
Gammaridae							
Eogammarus confervicolus			X	X		X	X
Insecta	Insects						
Coeoptera	Beetles	X	X	X		X	X
Chrysomelidae			X		X	X	X
Circulionidae		X	X			X	
Dytiscidae			X	X		X	X
Elmidae		X	X	X	X	X	X
Hydrophilidae		X	X			X	X
Staphylinidae		X	X			X	
Diptera	True Flies		X			X	
Chironomidae	Midges	X	X	X	X	X	X
Culicidae	Mosquitos	X	X	X		X	X
Simmulidae	Riffle Flies	X	X	X		X	X
Tipulidae	Crane Flies	X	X	X	X	X	X
Ephemeroptera	Mayflies						
Baetidae							
Baetis sp.			X	X	X	X	X
Heptageniidae							
Stenonema sp.		X		X		X	X

Appendix X. List of Organisms Identified in the Stomachs of Juvenile Chinook Salmon Collected During the 1986-1987 Study Periods. Mattole River Estuary/Lagoon, California. Taxonomic sources: Smith and Carlton eds. (1975); Borror et al. (1976); Barnes (1980); Merritt and Cummins eds. (1984)(continued).

Scientific Name	Common Name	June	July	Aug	Sept	1986	1987
Tricorythidae							
Tricorythodes sp.		X					X
Hemiptera	True Water-						
Corixidae	Bugs	X	X			X	X
Nacouridae							
Pelocris sp.		X		X		X	
Saldidae		X	X			X	X
Isocytus sp.			X			X	
Saldula sp.			X			X	
Homoptera							
Cicadellidae	Cicads	X	X	X	X	X	X
Hymenoptera	Bees, Wasps,	X				X	
Formicidae	Ants	X	X	X	X	X	X
Lepidoptera	Butterflies		X			X	
Megaloptera	Dobsonflies,						
Sialidae	Alderflies						
Sialis sp.					X		X
Odonata							
Anisoptera	Dragonflies						
Gomphidae			X	X		X	X

Appendix X. List of Organisms Identified in the Stomachs of Juvenile Chinook Salmon Collected During the 1986-1987 Study Periods. Mattole River Estuary/Lagoon, California. Taxonomic sources: Smith and Carlton eds. (1975); Borror et al. (1976); Barnes (1980); Merritt and Cummins eds. (1984)(continued).

Scientific Name	Common Name	June	July	Aug	Sept	1986	1987
Orthoptera	Grasshoppers,						
Tridactylidae	Crickets						
Neotridactylus apicialis		X		X		X	
Trichoptera	Caddisflies		X			X	
Hydroptilidae							
Oxyethira sp.					X		X
Sericostomatidae							
Gumaga griseus		X					X
II. Vertebrata							
Osteichthyes							
Gasterosteiformes							
Gasterosteidae							
Gasterosteus aculeatus	Threespine Stickleback		X	X		X	

Appendix Y. Summary of Juvenile Chinook Salmon Stomach Content Analysis, June 27, 1986. Mattole River Lagoon. #0 = Number of Occurences, %FO = Percent Frequency of Occurence, %N = Percent by Number, %V = Percent by Volume.

	NUMBER							VOLUME (ml)				
Taxon	Total	#O	%FO	%N	Mean	SD	SE	Total	%V	Mean	SD	SE
Amphipoda	17	1	7.1	11.0	1.2	2.8	0.8	0.05	9.1	0.004	0.01	0.00
Coleoptera	28	7	50.0	18.2	2.0	4.1	1.1	0.10	18.2	0.010	0.03	0.00
Diptera	72	13	92.9	46.8	5.1	4.8	1.3	0.05	9.1	0.004	0.01	0.00
Ephemeroptera	1	1	7.1	0.6	0.1	0.3	0.1	0.00	0.0	0.000	0.00	0.00
Hemiptera	4	4	28.6	2.6	0.3	0.5	0.1	0.05	9.1	0.004	0.01	0.00
Orthoptera	1	1	7.1	0.6	0.1	0.3	0.1	0.05	9.1	0.004	0.00	0.00
Hydracarina	2	1	7.1	1.3	0.1	0.5	0.1	0.00	0.0	0.000	0.00	0.00
Terrestrials	29	10	71.4	18.8	2.1	2.2	0.6	0.00	0.0	0.000	0.00	0.00
Combined Prey Items With Individual Volumes < 0.05 ml.								0.25	45.4	0.020	0.02	0.01
Totals (N = 14) Chinook Stomachs	154	14	100.0	100.0	11.0	10.8	2.9	0.55	100.0	0.039	0.04	0.01

Appendix Z. Summary of Juvenile Chinook Salmon Stomach Content Analysis, July 9, 1986.
Mattole River Lagoon. #0 = Number of Occurences, %FO = Percent Frequency of Occurence, %N = Percent by Number, %V = Percent by Volume.

	NUMBER							VOLUME (ml)				
Taxon	Total	#O	%FO	%N	Mean	SD	SE	Total	%V	Mean	SD	SE
Amphipoda	17	10	71.4	4.0	1.2	1.2	0.3	0.15	6.0	0.010	0.03	0.00
Isopoda	1	1	7.1	0.2	0.1	0.3	0.06	0.00	0.0	0.000	0.00	0.00
Mysidacea	1	1	7.1	0.2	0.1	0.3	0.06	0.00	0.0	0.000	0.00	0.00
Coleoptera	51	9	64.3	11.9	3.6	4.7	1.2	0.40	16.0	0.026	0.07	0.01
Diptera	176	12	85.7	41.0	12.6	16.8	4.3	0.40	16.0	0.026	0.04	0.01
Ephemeroptera	2	2	14.3	0.5	0.1	0.3	0.1	0.00	0.0	0.000	0.00	0.00
Hemiptera	35	35	35.7	8.2	2.5	3.8	1.0	0.45	18.0	0.030	0.05	0.01
Odonata	1	1	7.1	0.2	0.1	0.3	0.1	0.00	0.0	0.000	0.00	0.00
Trichoptera	1	1	7.1	0.2	0.1	0.3	0.06	0.00	0.0	0.000	0.00	0.00
Hydracarina	1	1	7.1	0.2	0.1	0.3	0.1	0.00	0.0	0.000	0.00	0.00
Terrestrials	144	9	64.3	33.6	10.3	14.2	3.7	0.80	32.0	0.050	0.09	0.02
Combined Prey Items With Individual Volumes < 0.05 ml.								0.30	12.0	0.021	0.03	0.01
Totals (N = 15) Chinook Stomachs	430	14	93.3	100	28.7	36.3	9.38	2.50	100	0.170	0.20	0.05

Appendix AA. Summary of Juvenile Chinook Salmon Stomach Content Analysis, July 24, 1986. Mattole River Lagoon. #0 = Number of Occurences, %FO = Percent Frequency of Occurence, %N = percent by Number, %V = Percent by Volume.

	NUMBER							VOLUME (ml)				
Taxon	Total	#O	%FO	%N	Mean	SD	SE	Total	%V	Mean	SD	SE
Amphipoda	8	3	33.3	4.6	0.7	1.5	0.4	0.00	0.0	0.000	0.00	0.00
Diptera	161	8	88.9	92.0	14.6	17.6	5.3	0.35	87.5	0.030	0.04	0.01
Ephemeroptera	2	1	11.1	1.1	0.2	0.6	0.2	0.00	0.0	0.000	0.00	0.00
Hemiptera	1	1	11.1	0.6	0.1	0.3	0.1	0.00	0.0	0.000	0.00	0.00
Lepidoptera	1	1	11.1	0.6	0.1	0.3	0.1	0.00	0.0	0.000	0.00	0.00
Terrestrials	2	1	12.8	1.1	0.2	0.4	0.1	0.00	0.0	0.000	0.00	0.00
Combined Prey Items With Individual Volumes < 0.05 ml.								0.05	12.5	0.004	0.00	0.00
Totals (N = 11) Chinook Stomachs	175	9	82	100	15.9	17.4	4.8	0.40	100	0.040	0.04	0.00

Appendix BB. Summary of Juvenile Chinook Salmon Stomach Content Analysis, August 12, 1986. Mattol River Lagoon. #0 = Number of Occurences, %FO = Percent Frequency of Occurence, %N = percent by Number, %V = Percent by Volume.

	NUMBER							VOLUME (ml)				
Taxon	Total	#O	%FO	%N	Mean	SD	SE	Total	%V	Mean	SD	SE
Amphipoda	24	5	71.4	22.6	3	3.2	1.11	0.3	21	0.04	0.04	0.01
Mysidacea	19	2	28.6	17.9	2.4	4.5	1.58	0.4	29	0.05	0.1	0.03
Coleoptera	3	1	14.3	2.8	0.4	1	0.35	0.05	4	0.01	0.02	0
Diptera	8	5	71.4	7.5	1	1	0.35	0	0	0	0	0
Ephemeroptera	2	2	28.6	1.9	0.3	0.4	0.15	0	0	0	0	0
Hemiptera	45	1	14.3	42.5	5.6	14.9	5.26	0.4	29	0.05	0.13	0.04
Odonata	1	1	8.2	0.9	0.1	0.3	0.11	0.05	4	0.01	0.02	0
Orthoptera	1	1	8.2	0.9	0.1	0.3	0.11	0.05	4	0.01	0.02	0
Osteichtyes	1	1	8.2	0.9	0.1	0.3	0.11	0.05	4	0.01	0.02	0
Terrestrials	2	2	28.6	1.9	0.3	0.4	0.15	0	0	0	0	0
Combined Prey Items With Individual Volumes < 0.05 ml.								0.1	7.2	0.0125	0.02	0.01
Totals (N = 8) Chinook Stomachs	106	7	87.5	100	13.3	17.1	6	0.4	100	0.18	0.17	0.06

Appendix CC. Summary of Juvenile Chinook Salmon Stomach Content Analysis, August 29, 1986. Mattole River Lagoon. #0 = Number of Occurences, %FO = Percent Frequency of Occurence, %N = Percent by Number, %V = Percent by Volume.

	NUMBER							VOLUME (ml)				
Taxon	Total	#O	%FO	%N	Mean	SD	SE	Total	%V	Mean	SD	SE
Amphipoda	8	7	77.8	16.7	0.5	0.6	0.2	0.00	0.0	0.000	0.00	0.00
Isopoda	1	1	11.1	2.1	0.1	0.2	0.1	0	0.0	0.000	0.00	0.00
Mysidacea	3	1	11.1	6.3	0.2	0.7	0.3	0.05	13.0	0.000	0.01	0.00
Coleoptera	5	3	33.3	10.4	0.3	0.8	0.3	0.05	13.0	0.000	0.01	0.00
Diptera	27	6	66.7	56.3	1.8	2.7	0.9	0.15	38.0	0.010	0.02	0.00
Ephemeroptera	1	1	11.1	2.1	0.1	0.2	0.1	0.00	0.0	0.000	0.00	0.00
Osteichtyes	1	1	11.1	2.1	0.1	0.2	0.1	0.05	13.0	0.000	0.01	0.00
Terrestrials	2	2	22.2	4.2	0.1	0.3	0.1	0.00	0.0	0.000	0.00	0.00
Combined Prey Items With Individual Volumes < 0.05 ml.								0.10	25.0	0.007	0.01	0.00
Totals (N = 15) Chinook Stomachs	48	9	64.2	100	3.2	4.3	1.1	0.40	100	0.030	0.04	0.01

Appendix DD. Summary of Juvenile Chinook Salmon Stomach Content Analysis, June 22, 1987. Mattole River Lagoon. #0 = Number of Occurences, %FO = Percent Frequency of Occurence, %N = Percent by Number, %V = Percent by Volume.

	NUMBER							VOLUME (ml)				
Taxon	Total	#O	%FO	%N	Mean	SD	SE	Total	%V	Mean	SD	SE
Amphipoda	5	4	33.3	4.2	0.3	0.6	0.2	0.00	0.0	0.000	0.00	0.00
Isopoda	1	1	8.3	0.8	0.07	0.25	0.1	0.00	0.0	0.000	0.00	0.00
Coleoptera	3	3	25.0	2.5	0.2	0.4	0.1	0.00	0.0	0.000	0.00	0.00
Diptera	75	12	100	63.0	5.0	5.0	1.3	0.20	57.0	0.013	0.00	0.00
Ephemeroptera	8	2	16.7	6.7	0.5	1.5	0.4	0.00	0.0	0.000	0.00	0.00
Hemiptera	5	3	25	4.2	0.33	0.7	0.18	0.00	0.0	0.000	0.00	0.00
Odonata	1	1	8.3	0.8	0.07	0.25	0.06	0.00	0.0	0.000	0.00	0.00
Trichoptera	10	3	25	8.4	0.67	1.45	0.37	0.10	29.0	0.007	0.00	0.00
Hydracarina	2	2	16.7	1.7	0.13	0.34	0.08	0.00	0.0	0.000	0.00	0.00
Oligochaeta	1	1	8.3	0.8	0.07	0.25	0.1	0.00	0.0	0.000	0.00	0.00
Terrestrials	8	4	33.3	6.7	0.5	1.0	0.2	0.00	0.0	0.000	0.00	0.00
Combined Prey Items With Individual Volumes < 0.05 ml.								0.05	14.3	0.003	0.01	0.00
Totals (N = 15) Chinook Stomachs	119	12	80	100	7.9	7.3	1.9	0.40	100	0.020	0.02	0.01

Appendix EE. Summary of Juvenile Chinook Salmon Stomach Content Analysis, July 21, 1987. Mattole River Lagoon. #0 = Number of Occurences, %FO = Percent Frequency of Occurence, %N = Percent by Number, %V = Percent by Volume.

	NUMBER							VOLUME (ml)				
Taxon	Total	#O	%FO	%N	Mean	SD	SE	Total	%V	Mean	SD	SE
Amphipoda	17	9	81.8	10.5	1.1	1.1	0.3	0.00	0.0	0.000	0.00	0.00
Isopoda	1	1	9.1	1	0.1	0.25	0.1	0.00	0.0	0.000	0.00	0.00
Coleoptera	1	1	9.1	0.6	0.1	0.3	0.1	0.00	0.0	0.000	0.00	0.00
Diptera	142	11	100	87.7	9.5	11.2	2.9	0.50	83.0	0.030	0.04	0.01
Terrestrials	2	2	18.2	1.2	0.1	0.3	0.1	0.00	0.0	0.000	0.00	0.00
Combined Prey Items With Individual Volumes < 0.05 ml.								0.10	17.0	0.001	0.02	0.00
Totals (N = 15) Chinook Stomachs	162	11	73.3	100	10.8	11.63	3.0	0.60	100	0.040	0.04	0.01

Appendix FF. Summary of Juvenile Chinook Salmon Stomach Content Analysis, August 23, 1987. Mattole River Lagoon. #0 = Number of Occurences, %FO = Percent Frequency of Occurence, %N = Percent by Number, %V = Percent by Volume.

	NUMBER							VOLUME (ml)				
Taxon	Total	#O	%FO	%N	Mean	SD	SE	Total	%V	Mean	SD	SE
Amphipoda	10	4	57.1	4.2	1.3	1.6	0.6	0.15	19.0	0.020	0.03	0.01
Isopoda	19	1	14.3	7.9	2.4	6.28	2.2	0.05	6.0	0.010	0.02	0.00
Coleoptera	6	5	71.4	2.5	0.8	0.7	0.2	0.00	0.0	0.000	0.00	0.00
Diptera	105	7	100	43.8	13.1	10.9	3.9	0.40	50.0	0.050	0.05	0.01
Ephemeroptera	46	4	57.1	19.2	5.8	7.64	2.7	0	0.0	0.000	0.00	0.00
Hydracarina	48	1	14.3	20	6.0	15.8	5.61	0	0.0	0.000	0.00	0.00
Terrestrials	6	4	57.1	2.5	0.8	0.8	0.3	0.00	0.0	0.000	0.00	0.00
Combined Prey Items With Individual Volumes < 0.05 ml.								0.20	25.0	0.003	0.02	0.01
Totals (N = 8) Chinook Stomachs	240	7	87.5	100	30.0	39.98	14.1	0.80	100	0.100	0.08	0.03

Appendix GG. Summary of Juvenile Chinook Salmon Stomach Content Analysis, September 19, 1987. Mattole River Lagoon. #0 = Number of Occurences, %FO = Percent Frequency of Occurence, %N = Percent by Number, %V = Percent by Volume.

	NUMBER							VOLUME (ml)				
Taxon	Total	#O	%FO	%N	Mean	SD	SE	Total	%V	Mean	SD	SE
Amphipoda	7	3	42.9	2.9	0.9	1.6	0.57	0.00	0.0	0.000	0.00	0.00
Isopoda	17	4	57.1	7	2.1	2.5	0.89	0.10	7.0	0.013	0.02	0.00
Coleoptera	2	2	28.6	0.8	0.3	0.4	0.15	0.00	0.0	0.000	0.00	0.00
Diptera	188	6	86	77.4	23.5	17.7	6.25	1.10	76.0	0.140	0.13	0.04
Ephemeroptera	4	1	14.3	1.6	0.5	1.3	0.46	0.00	0.0	0.000	0.00	0.00
Hemiptera	2	1	14.3	0.8	0.3	0.7	0.23	0.05	3.0	0.006	0.02	0.00
Megaloptera	1	1	14.3	0.4	0.1	0.3	0.11	0.00	0.0	0.000	0.00	0.00
Trichoptera	2	1	14.3	0.8	0.3	0.7	0.23	0.00	0.0	0.000	0.00	0.00
Terrestrials	20	4	57.1	8.2	2.5	4.2	1.47	0.10	7.0	0.013	0.02	0.00
Combined Prey Items With Individual Volumes < 0.05 ml.								0.10	7.0	0.013	0.02	0.00
Totals (N = 8) Chinook Stomachs	243	7	87.5	100	30.4	0.8	6.8	1.45	100	0.180	0.14	0.05

Appendix HH. Summary of Johnson (1980) Diet Preference Analyses, Juvenile Chinook Salmon, 1986 Mattole River Estuary/ Lagoon, Numeric Data. Preference Values of Taxa Sharing the Same Line are Not Significantly Different.

DATE - June 27

Taxonomic Group	tBar
Diptera	-3.5
Terrestrials	-2.7
Coleoptera	-1.6
Hemiptera	-0.2
Orthoptera	0.2

DATE - July 09

Taxonomic Group	tBar
Terrestrials	-4.4
Hemiptera	-2.5
Diptera	-1.9
Ephemeroptera	-1.4
Mysidacea	-1.1

DATE - July 24

Taxonomic Group	tBar
Ephemeroptera	-0.6
Hemiptera	-0.5
Diptera	-0.5
Terrestrials	-0.5
Lepidoptera	-0.3

DATE - August 12[1]

Taxonomic Group	tBar
Diptera	-0.9
Amphipoda	-0.2
Mysidacea	1.2

DATE - August 29

Taxonomic Group	tBar
Coleoptera	-2.8
Ephemeroptera	-2.5
Terrestrials	-0.7
Osteichthyes	-0.5
Isopoda	1.0

DATE - 1986 Overall

Taxonomic Group	tBar
Terrestrials	-6
Hemiptera	-6
Ephemeroptera	-5.5
Isopoda	-4.5
Diptera	-3.0

[1]Only three taxa occured frequently enough to be included in analysis.

Appendix II. Summary of Johnson (1980) Diet Preference Analyses, Juvenile Chinook Salmon, 1987 Mattole River Estuary/ Lagoon, Numeric Data. Preference Values of Taxa Sharing the Same Line are not Significantly Different.

DATE - June 22

Taxonomic Group	tBar
Hemiptera	-3.8
Ephemeroptera	-3.6
Odonata	-3.1
Terrestrials	-0.8
Amphipoda	-0.6

DATE - July 21

Taxonomic Group	tBar
Amphipoda	-2.7
Terrestrials	0.1
Isopoda	0.2
Diptera	0.7
Coleoptera	1.7

DATE - August 23

Taxonomic Group	tBar
Isopoda	-1.4
Ephemeroptera	-1.3
Diptera	-0.2
Amphipoda	0.4
Hydracarina	2.5

DATE - September 19[1]

Taxonomic Group	tBar
Terrestrials	-1.2
Amphipoda	0.1
Diptera	0.4
Isopoda	0.7

DATE - 1987 Overall

Taxonomic Group	tBar
Ephemeroptera	-4.0
Terrestrials	-3.0
Hydracarina	-1.0
Odonata	-0.5
Diptera	0.0

DATE - 1987 Overall (Volumetric Data)

Taxonomic Group	tBar
Diptera	-2.0
Terrestrials	-0.5
Hemiptera	0.0
Isopoda	0.5
Amphipoda	1.5

[1] Only four taxa occured frequently enough to be included in analysis.

Appendix JJ. Summary of Regression Analyses of Numbers of Amphipods in Epibenthic Samp
Versus Water Quality Data at Bottom Depth, Mattole River Estuary/Lagoon 19
(Barnhart and Busby 1986).

LOWER SITE

	June 27	July 2	July 25	Aug 26	Sept 13	Oct 27	R^2
# of Amphipods	309	400	434	159		52	
Temperature (°C)	21.0	21.0	18.5	20.5		14.0	0.37
Salinity (ppt)	10.2	0.2	9.5	0.0		0.0	0.32
Dissolved O_2(ppm)	15.0	8.4	8.0	8.2		9.3	0.00

UPPER SITE

	June 27	July 2	July 25	Aug 26	Sept 13	Oct 27	R^2
# of Amphipods	53	58	169	512	635	58	
Temperature (°C)	20.0	19.1	23.0	23.0	16.5	17.0	0.00
Salinity (ppt)	6.5	0.3	12.0	0.0	0.0	14.5	0.35
Dissolved O_2(ppm)		7.5	14.0	7.4	11.0	8.2	0.08

Appendix KK. Summary of Regression Analyses of Densities of Amphipods in Epibenthic Samples Versus Water Quality Data at Bottom Depth, Mattole River Estuary/Lagoon 1987 (Busby et al. 1988).

LOWER SITE

	July 31	Sept 2	Oct 3	Nov 1	R^2
#/m^2 Amphipods	9	73	28	159	
Temperature (°C)	19.0	18.0	15.0	14.8	0.30
Salinity (ppt)	0.0	0.0	17.5	8.2	0.10
Dissolved O_2 (ppm)	7.9	10.5	8.2	5.2	0.31

UPPER SITE

	July 31	Sept 2	Oct 3	Nov 1	R^2
#/m^2 Amphipods	198	272	155	145	
Temperature (°C)	20.0	16.9	16.5	14.8	0.12
Salinity (ppt)	0.0	0.0	16.0	6.0	0.46
Dissolved O_2 (ppm)	8.9	10.7	6.1	4.7	0.91

Appendix LL. Summary of Regression Analyses of Numbers of Planktonic Organisms versus Water Quality Data at Mid-Depth, Mattole River Estuary/Lagoon 1986 (Barnhart and Busby 1986).

	June 18	July 2	July 25	Aug 8	Aug 26	Sept 13	R^2
LOWER SITE							
# of Organisms	17	145	849	448	746	794	
Temperature (°C)	20.7	21.0	19.0	18.5	20.5	18.0	0.40
Salinity (ppt)	0.5	0.2	4.0	0.0	0.0	0.0	0.15
Dissolved O_2 (ppm)	8.0	8.4	8.2	10.2	8.2	9.7	0.05
UPPER SITE							
# of Organisms		283	335	62	2070	1557	
Temperature (°C)		19.2	20.5	18.0	23.0	16.5	0.11
Salinity (ppt)		0.3	0.0	0.0	0.0	0.0	0.13
Dissolved O_2 (ppm)		8.2	9.2	8.2	7.3	10.4	0.00

Appendix MM. Summary of Regression Analyses of Daytime Concentrations of Planktoni Organisms Versus Daytime Water Quality Data at Mid-Depth, Mattole Ri Estuary/Lagoon 1987 (Busby et al. 1988).

LOWER SITE

	July 7	Aug 9	Sept 9	Oct 7	R^2
# of Organisms/m^3	1.3	3.4	3.8	16.0	
Temperature (C)	17.8	17.5	18.0	17.0	0.75
Salinity (ppt)	0.0	0.1	0.0	14.0	0.97
Dissolved O_2 (ppm)	7.9	7.8	8.9	9.8	0.79

UPPER SITE

	July 7	Aug 9	Sept 9	Oct 7	R^2
# of Organisms/m^3		0.3	1.0	316.0	77.3
Temperature (C)	19.0	18.0	16.5	17.8	0.83
Salinity (ppt)	0.0	0.0	0.0	4.9	0.09
Dissolved O_2 (ppm)	9.2	8.3	7.0	8.0	0.81